School Science

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Articles suitable to the objectives mentioned above are invited for publication. An article sent for publication should normally not exceed ten typed pages, and it should be exclusive to this journal. Illustrations should be drawn with pen and indelible ink. Photographs (black and white), at least of postcard size, should be on glossy paper and should be properly packed to avoid damage in transit.

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Measuring Focal Length of a Lens of Low Power Using a Laser

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Theory and Basic Method

CONSIDER a lens of focal length f. If f is positive (i.e. a converging lens), then two rays parallel to its principal axis meeting the lens at points A and B, pass through the focal point F after refraction through the lens (Fig. 1). Distance OF ($\approx$ AF $\approx$ BF) is defined as focal length of the lens.

Consider a screen S placed between the lens and F. If the lens was not there, the two rays would have gone straight and thus reached points C and E respectively on the screen. Same will happen if lens is placed with its optical centre at A for the first ray and at B for second ray. Thus downward shift of lens through AO shifts the spot on the screen in the same direction from C to C' for the first ray (Fig. 2). Similarly, for second ray, upward shift of lens through BO, shifts the spot on the screen in the same direction from E to E' (Fig. 1). Thus a shift of spot on the screen in the same direction as shift of lens indicates that it is a positive lens (i.e. a converging lens). A shift of spot on the screen in opposite direction to shift of lens indicates that it is a negative lens (i.e. a diverging lens).

Now ∧s ACC' and FOA (Fig. 1) are similar

$$\therefore \frac{CC'}{AC} = \frac{AO}{FO} \qquad \ldots(1)$$

$$\text{or } f = \frac{d}{x} \cdot \theta \qquad \ldots(2)$$

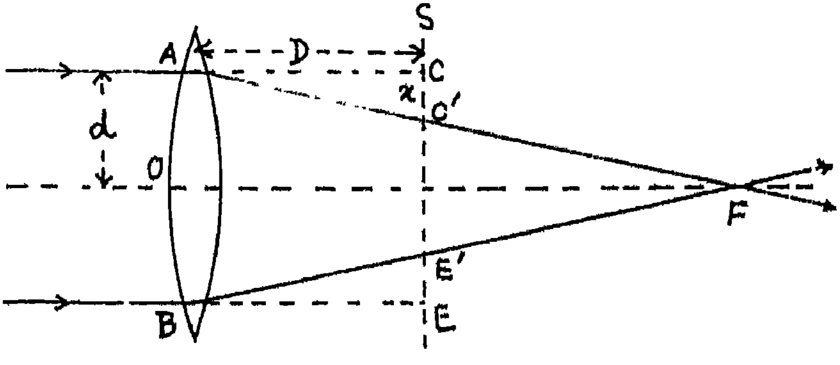

Fig. 1. Distance OF ≈ AF ≈ BF is focal length

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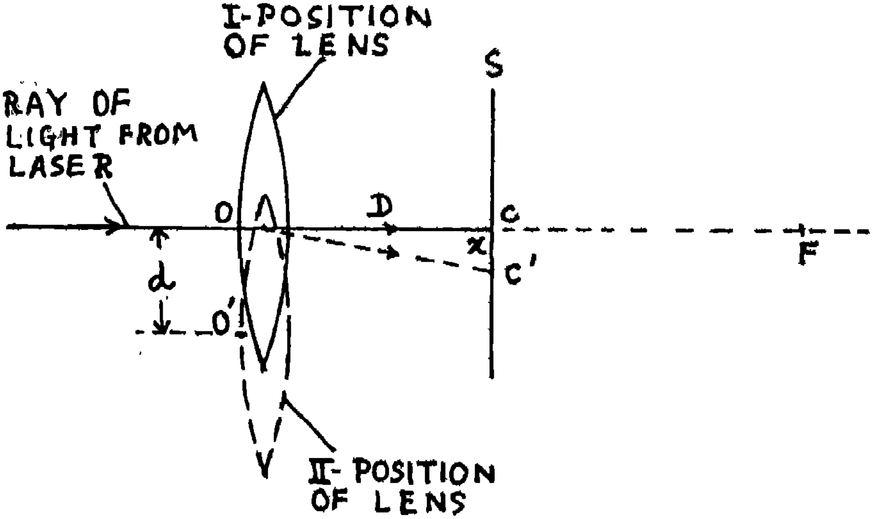

Fig. 2. Shift of lens from O to O', shifts the spot of light on the screen from C to C'

Where

AC = D = the distance between lens and screen

AO = d = the shift of lens, and

CC' = x = the shift of spot of light on screen caused by shifting the lens.

Thus by measuring d, D and x, the value of f can be calculated, even if f is much larger than distance D available in the laboratory.

A Source of Error and Its Elimination

Consider a spectacle lens of zero power. One surface of this lens is convex and the other is concave and both have same radius of curvature. A ray of light through its centre O and parallel to its principal axis, goes on without any change of direction or any lateral displacement (Fig. 3). But rays parallel to principal axis passing through points A and B get a lateral displacement. Shift of spots observed on screen S, when compared to Fig. 1, gives the impression that it is a converging lens. The shift of spots on the screen in both cases is similar. If the lens is reversed and the rays enter its concave face, then the shifts of spots observed on screen S are opposite to that shown in Fig. 3 and give the impression that of a diverging lens.

Due to finite thickness of any lens, such displacement of rays passing through it and falling on the screen S causes a small error in the observed

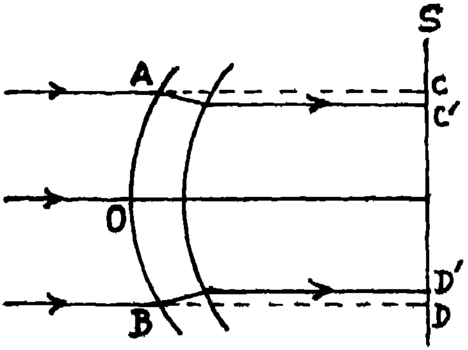

Fig. 3. A ray of light incident on convex surface of a lens of zero power, undergoes lateral displacements by which the lens appears to be a converging lens in this method of measuring focal length

value of x in the experiment of finding its focal length by eqn (2). This error in x is eliminated, if two measurements of x are made, one with the laser beam entering one face of the lens and the other with the beam entering the other face of the lens, by reversing the lens. Mean of the two observations of x for the same shift α of the lens, gives true value of x caused purely by change in direction of the ray by this shift of the lens.

Alternative Method to Measure (x) Precisely

According to eqn(1) shift of spot (CC') is proportional to shift of lens (AO), because in a particular experimental setting AC and OF are constant. It is clear that initial position of the lens (Fig. 2) need not be with its optical centre O in the path of the ray. Any point of the lens on its diameter AOB (Fig. 1) can be kept on the path of the ray, in its initial position. Similarly, any other point on this diameter can be brought in the path of the ray in the shifted position of the lens. Thus eqn(2) holds true for any shift, α, of lens and corresponding shift, x, of the light spot on the screen, as long as the lens is so shifted that all points at which the ray meets the lens in various positions, lie on the diameter AOB of the lens. These points must constitute a diameter passing through optical centre of the lens. This clarification facilitates accurate measurement of x by the following procedure.

A good graph paper makes the vertical screen S (Fig. 4). This diagram is drawn as seen from above. The graph paper for this purpose should be the one with blue lines of darkest available shade so as to be clearly visible in red light of laser. The lens is mounted in a stand which can slide on a horizontal drawing board, on which another identical graph paper is attached. A straight edge (e.g. a ruler) is also attached on the drawing board along with the lens stand can slide. Along the line of graph paper on which this straight edge is fixed, a scale is written to read the position of the reference end of the lens stand. Readings of this reference end enable us to measure lateral shift, d, of the lens.

Laser beam makes a tiny spot on

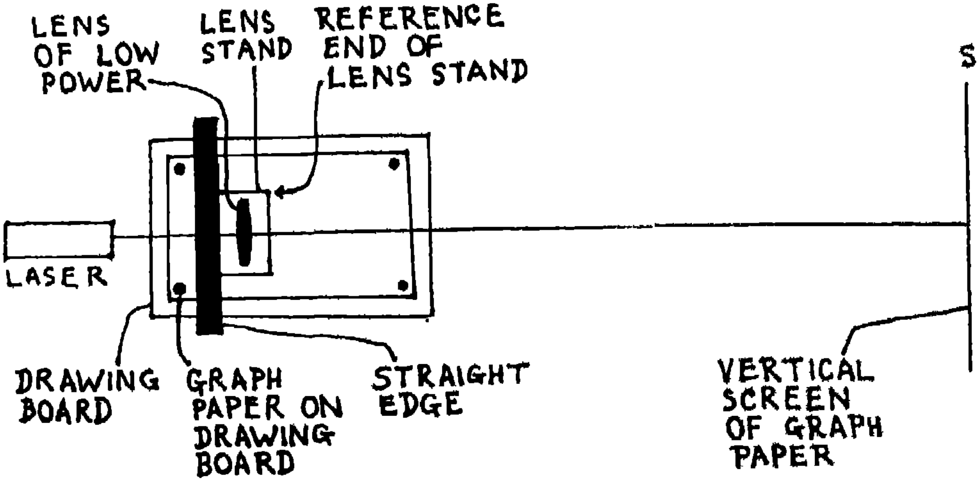
LENS OF LOW POWER
LENS STAND
REFERENCE END OF LENS STAND
S
LASER
DRAWING BOARD
GRAPH PAPER ON DRAWING BOARD
STRAIGHT EDGE
VERTICAL SCREEN OF GRAPH PAPER

Fig. 4. View of the set-up for the precision measurement of x, as seen from above

the screen. Diode laser makes an elliptical spot of about 3 mm and 1.5 mm as its axes at a distance of 1 metre, or about 11 mm and 6 mm at a distance of 6 metre. Referring to Fig. 5, a scale is written along a horizontal line on the screen to read position of the spot of light. The spot of light should be above or below this line, and its position can be read with the help of vertical lines of the graph paper.

The spot of light falls on the vertical zero-line of the graph paper screen (Fig. 5), when the laser beam passes through optical centre of the lens. The spot of the light extends symmetrically on either sides of the zero line. Thus the zero-line passes through its centre. This judgement can be easily made correct to a small fraction of a millimetre. Some diode lasers produce a spot of light with a fine black line passing through its centre. Then, let this black line coincide with the zero line.

In shifted position of the lens, new position of this spot is read on the graph paper to find its shift, x. The magnitude of shift, d, of lens is so adjusted that x is a whole number of millimetres. Thus, in its shifted position also, the spot of light falls on another vertical line of graph paper, which passes through its centre (Fig. 5). Thus the value of x is observed with a precision of a small fraction of a millimetre. In contrast, when position of spot is any where on the scale, it can be read with less precision and error in x is of the order of an mm.

Shift, d, of the lens, being much larger than x, may be read to the nearest mm. In this procedure, when

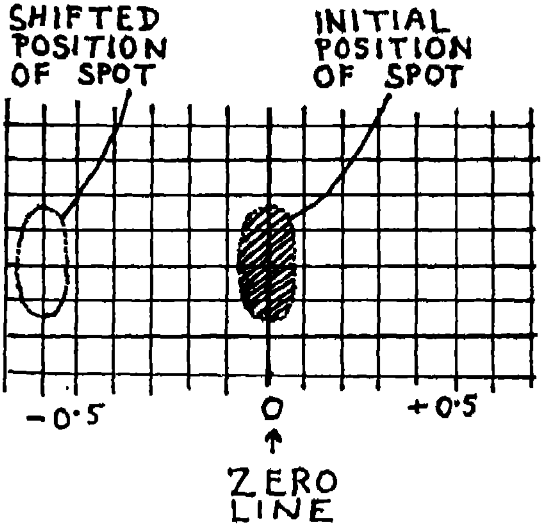

Fig. 5. Precision measurement of shift of spot of light, x, on the vertical screen of graph paper by making it a whole number of millimetres

lens is reversed for second reading, then *x* is kept the same and second value of *d* is obtained. Then mean of the two values of d for same *x* is taken.

It may be argued that the scale on graph paper to measure *x*, may itself have much error. Thus, for example, 5 cm on graph paper may be actually 5.1 cm or even 5.2 cm measured by an accurate scale. But, when identical graph papers are used to measure *x* and *d*, such errors will be same in both and their ratio in eqn(2) will not be affected by this error. On the drawing board and on the screen, the graph papers should either be stuck by a glue which does not change their size, or should be simply pinned.

Experimental Findings

A spectacle lens claimed to be of zero power and of diameter 6 cm was obtained from a spectacles shop. This lens was tested by a student of St. Francis De Sales Senior Secondary School for his project work in the guidance of the author and Physics Teacher of the school, using this method.

The distance, D, between lens and screen available in the laboratory was about 4.5 m. By making measurements as above, it was found that power of the lens was about −0.020 dioptre, indicating that it is a diverging lens. Difference between the highest and lowest results in a set of six repeat observations was about 0.005 dioptre, when author repeated the experiment by the alternative method of measuring *x* precisely, with same value of D.

Acknowledgements

Thanks are due to Sri N.H. Krishnan and Smt. Anila Kalra, Post-Graduate Teachers of Physics at St. Francis De Sales Senior Secondary School, Block C2, Janakpuri, New Delhi 110058, for their initiative in organising laser projects with their students and thus giving a situation where innovative projects were developed. Sri N.H. Krishnan also read through the draft of this article and helped to improve it. The procedure for precision measurement of *x* described above was thought out after the student's experiment and tried out by the author at home.

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Stones in Your Gall Bladder

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GALL STONES were described as calculi in human livers by Alexander of Tralles, a physician of Byzantine Empire. Around 1500 BC, these were localized in mummified Egyptian priestess. Gall stones are currently the most common digestive cause of hospital admission throughout the world. Third world countries which are now adopting western dietary pattern are showing increase in the incidence of gall stones. The rapidly rising incidence of gall stones, particularly that of cholesterol, is increasingly taxing already overburdened and under resourced health system of third world. The old concept of gall stones disease occurring mainly in fat, fertile, flamboyant females in their forties is changing. Gall stones occur in all societies and races, in young and old people of both sexes, and in all states of health. However, incidence of gall stones rises with age, during pregnancy, obesity and increased caloric intake.

Gall bladder is pear-shaped reservoir of bile, present within liver. It stores, concentrates and regulates the flow of bile, a fluid produced by liver. This fluid is rich in fatty substances, particularly cholesterol — which are extracted from blood by the liver. It also contains a pigment billirubin, formed by breakdown of old red blood cells and bile acids. After a meal, gall bladder is stimulated to contract and it releases small amount of bile into the duodenum, where it helps in digestion of fats. Normally, cholesterol is held in solution form by bile acids. But in some individuals cholesterol solubility is reduced due to its hypersecretion. Super saturation of bile with cholesterol enhances nucleation which results in crystal formation. A gall stone in the beginning is formed as a tiny solid particle which grows as more material solidifies around it. With stones gall bladder motility is impaired and this stagnates the bile and further facilitates the growth of crystals. Gall stones (Cholelithiasis) are made up of cholesterol or bilirubin and or calcium. Calcium bilirubinate pigment stone formation results from supersaturation of bile with calcium bilirubinate.

Patients with gall stones fall into three groups—those who have symptoms (Symptomatic gall stones), those who do not have symptoms (Asymptomatic gall stones), and those whose condition is complicated by cholecystitis, pancreatitis or obstructive jaundice (Complicated gall stones). Symptomatic gall stones travel with bile along the bile duct, where they may get stuck. If this happens, the result is an intense pain in the upper-right hand abdomen. It is called 'biliary colic'. If the stone falls back into the gall bladder, or is forced along the bile duct and passes into the duodenum, then the pain subsides.

Other symptoms of these stones include abdominal discomfort, bloating, belching and intolerance to fried food. Symptoms are the most reliable factors indicating the prognosis and hence the necessity for treatment. Once stones are symptomatic, worsening of symptoms is likely and the risk of progression to more severe disease such as acute cholecystitis or pancreatitis is increased. Many asymptomatic gall stones are discovered incidentally during investigations of other problems or go undiscovered. Most gall stones that are asymptomatic remain so. However, roughly 10% of patients with asymptomatic stones develop symptoms within five years of diagnosis. The risk of gall bladder cancer is increased by asymptomatic stones but statistically still remains very low and cannot usually be taken as justification for prophylatic cholecystectomy in asymptomatic patients. As a general rule asymptomatic gall stones should be left *in situ* except in some special cases. Cholecystitis and choledocholithiasis with or without pancreatitis, are the most common complications of gall stone disease. The chronic low grade inflammation caused by gall bladder stones, infection of gall bladder bile and intermittent duct obstruction results in scarring, contracture and loss of function of gall bladder wall.

The least invasive, safest, most cost effective diagnostic modality currently available is abdominal ultrasound scanning. In skilled hands, the sensitivity and specificity of ultrasonography in the detection of gall bladder stones exceed 90%. Stones in the common bile duct (Choledocholithiasis) are more difficult to detect Radio-nuclide biliary scanning is a valuable and sensitive tool for confirming the diagnosis. The aim of the treatment is the elimination of troublesome stones and to avoid the risk of their recurrence. Cholecystectomy i.e., removal of gall bladder is the most cost effective and the only reliable method of achieving this. The first cholecystectomy was carried out in 1882 by Carl von Langenbuch. The safety and success of this operation was soon established and it still remains the treatment of choice for symptomatic gall stones. Throughout the world cholecystectomy is now available either as open operation, requiring upper abdominal laparotomy or as a laparoscopic (closed or minimally invasive) operation. With surgery stones infested gall bladder along with stones in the rest of the biliary tree, if necessary, is removed without injuring the surrounding organs. After surgery patient is advised to have fat-restricted diet for few months. Then a normal diet is resumed.

Non surgical options available include gall stone dissolution therapy, extracorporeal shock wave lithotripsy, and mechanical litholysis. Gall stone dissolution may be achieved by oral bile acid treatment with chenodeoxycholic acid or ursodeoxycholic acid or by the use of solvents such as methyl tert-butyl ether instilled directly into gall bladder or bile duct after endoscopic intubation. Gall stones are most suitable for dissolution treatment when the gall bladder retains at least 50% of normal contractility, and the stones are smaller than one cm diameter, occupy less than 40% of the gall bladder volume, are non-calcified and are of cholesterol or mixed type. It is frequently employed in conjunction with extra corporeal shock wave lithotripsy or endoscopic techniques. Extracorporeal shock wave lithotripsy uses computer focused shock waves produced outside the body by electromagnetic or ultrasound sources to fragment gall stones. Stone fragments are then passed out of the biliary tree into the duodenum. Mechanical fragmentation of stones, by crushing with forceps or with laser or ultrasound devises, can also allow clearance of stones from the gall bladder and bile duct without gall bladder removal. However, non-surgical options are suitable for only about one-fifth of patients having a higher gall stone recurrence rate, and are also not without risks. After gall bladder removal most of our ability to store and then release bile after meal is generally seen as well tolerated change. It is expected that in the new millennium patients will be operated by means of video-laparoscopic techniques giving them much faster relief.

Teaching of Science and Technology at School Level

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IN THE LAST few decades, there has been an industrial revolution in the entire world due to science and technology. Pure and applied scientific researches appeared as a key to the technological progress. Consequently, the relation between science and technology has become truly institutionalised as evident by the place occupied by science and technology policy in the national policy.

Considering the relevance of *science and technology*, the *National Curriculum Framework for School Education*, brought out by the NCERT in the year 2000, recommends the teaching of *science and technology* as one of the subject areas in place of science at upper primary and secondary levels. The document advocates strongly that technology should be integrated with science teaching at upper primary and secondary levels and the main aim should be *providing scientific and technological literacy*. This paper discusses why science should be taught as *'science and technology*, and what should be the main focus and purpose at these levels. Paper also covers the broad approach of teaching science and technology at these levels.

What is Science and What is Technology ?

The world 'Science' is derived from the Latin root 'Scire' which means 'to know'. Thus, the original meaning of Science is simply 'Knowledge', although it generally deals with natural and material phenomena and is based mainly on observation, experiment and induction. The word technology is derived from the Greek root 'techne' meaning 'art', and is thus translated as *Science of Industrial Art*. On the basis of these aforesaid definitions, while science is concerned with the fundamental knowledge of our world and its environment, technology deals with the numerous ways and means of pressing science into human services, of making or changing things for public ends.

Science is universal. It does not vary with geography of place or with economic, social or political conditions. Principles or laws of science verified in any part of the world give the same result. This is not true with technology. Technology as practised tends to be more national. Technology may depend upon economic, geographical, social and political conditions. It is obvious, while science may be considered as neutral or amoral, technology can acquire ethical, moral overtones and invite to itself labels like 'moral' or 'immoral', 'human' or 'cruel' even 'socialistic' or 'capitalistic'. Science connotes power, but without any sense of direction implied for that power. Technology confers a direction to that power and, therefore, deeply influences society. Science and technology are jointly responsible for improving the *quality of life*.

Science as mentioned above, is basically an *objective knowledge*. it searches the reality or truth behind a natural phenomena or about a material substance, through its *processes*. The value of truth is value of Science. It is really strange that Science and Technology which are capable of serving the masses, are not produced by masses, but are produced by scientists and technologists.

Nature of Science and Technology

The science and scientific knowledge (concepts, generalization and theory) are of a definite nature, some salient points are worth mentioning in this context. They are as following :

(i) Science is a human attempt to generate testable concepts, generalization and theories which explain natural phenomena and have *predictive capabilities*.

(ii) Scientific explanations are based on data derived from observations and experiments which are *public* and *replicable* (This means that scientific knowledge, if reproduced and supported by a majority of scientists, becomes a part of fabric of science).

(iii) Scientific knowledge is *tentative* and subject to revisions in the light of the new findings and evidences.

(iv) Scientific knowledge is *historic* i.e. scientific knowledge of the past has provided the basis for tomorrow's knowledge. Knowledge of the past should not be seen in historical perspective, if and when it differs from the present knowledge, the former should not be degraded.

(v) Scientific knowledge is derived from observations and controlled experimentation.

(vi) As a creative human imagination, concepts of science reflect the social and cultural background of their times.

(vii) Scientific knowledge is itself normally neutral, but the use to which it is put and the reason for which it is sought, may involve *moral judgement*.

Scientific knowledge is valued for at least two reasons :

(a) It can satisfy some aspects of our inherent curiosity through rational explanation of natural phenomena, and can predict *certain* natural events.

(b) It makes an impact through its applicability to things which concern individuals and groups.

In the words of Bacon, the scientific knowledge is *power*. There is no place for *trial* and *error* in solving problems.

Problems can be solved by scientific principles, taking technology as a tool. In his view, if there is no *cause-effect relationship* and its *events are not reproducible*, then science will be pointless endeavour.

Coming to *nature of technology education*,we find that it is not universal like science. It depends on various geographical, social and economic conditions of a place/nation. Technology a country chooses to use is largely a matter of national policy. Global survival imposes certain constraints, as does the availability of *material and energy*.

Knowledge of technology is developed commulatively, through use and modifications i.e. *trial and error*. Upto the beginning of the nineteenth century, science and technology were quite independent but in the later part of the century, science and technology were quite interdependent. Out of three major revolutions — mechanical, electrical and electronic, the latter two are very closely dependent on scientific knowledge. There is, although inaccurate, a linear relationship between scientific research and technological artefact. This image has experiment leading to theory, and then to invention, to development, to innovation, to products, and finally to social impact.

Science and Technology Teaching at School Level

There is a strong feeling that introduction of technology along with science and giving the name *Science and Technology* as a subject at upper primary and secondary levels is being done for the first time and there was no technology earlier in science teaching. This is not true. In fact, it is not possible to demarcate a boundary and separate science and technology from each other. Science and technology affect our life and therefore, is an important issue now to apprise students that science and technology go hand in hand. However, there will be a paradigm shift as far development of new textbooks and related instructional materials are concerned. Use of technology is a delivery device. It is through technology that we reap the crop of science.

(a) What kind of Technology is already in the existing Science courses upto Secondary level ?

- Processes of science basically are manifestation of technology which include designing, performing experiments, improvisation and using appropriate technological devices.
- Handling many instruments and equipment based on scientific principles/theories and laws.
- Project work involving various technologies/methods.
- Study of various industrial processes and getting various types of products (substances and materials) out of them.
- Design and development of various static and working models, designing of various devices, circuits or appropriate methods for *solving problems* and teaching environmental, industrial and agricultural issues.

All the above aspects are already provided in School Science curriculum and tentatively these are provided to an extent of approximately 25% of the total quantum of science content covered at school level.

(b) What should go in textbooks and how ?

- *Developing Concepts in Science and Integrating with Technology* : Science activities should be introduced and as far as possible concepts should be developed around experiments/activities. Here 'introduction of different types' of activities also are a form of technology. Apparatus and equipment for scientific activities may be improvised if adequate facilities are not available in the form of ready-made apparatus/equipment. In other words, in some cases for the same type of science concepts, equipment may be simple and in some cases they may be rather complex or sophisticated. In other words, science does not change but technology will change depending upon the facilities/situation/resources etc.

(ii) *How can we make 'Science' to be 'Science and Technology' ?*

- Providing more activities, experiments, improvisations, models, designs/circuits etc.
- More emphasis on processes rather than on products of science, and
- Providing linkages of science with industries, agriculture, environment, conservation of natural resources, population, energy, etc.

How Scientific Concepts and Technological Applications should be Woven ?

- We should start with application of science and provide how principles of science have been applied through technology for improving our life situations (applications).

Various societal *issues* and *concerns* should be identified and discussed and their solutions should be worked out using scientific concepts and appropriate technology. How technology has helped in overcoming these problems? Some of the relevant areas of immediate concerns may be referred for illustraions: agriculture (agricultural bio-diversity), environment degradation, energy crisis, health and nutrition, industrial production, different types of materials and their industrial uses, population explosion, conservation of petroleum and petroleum products.

It would be relevant to discuss how technology has been useful in increasing production in agriculture (How to overcome food shortage?). Creating new varieties of crops (which are high yielding variety and take less time in producing grain/fruits), how far bio-diversity is meaningful and should be encouraged. How various scientific principles/concepts used in industries are helping the nation in its economic growth, chemical industries, electronic industries, etc.? For example, how we can get silicon and germanium of high purity. What are efficient rocket fuels for space exploration, etc.?

How industries, which are inevitable, create pollution (air, water, soil pollutions and as such should operate under the principle of *sustainable development* ? How to bring down the level of pollution and improve the quality of environment ? Industrial effluent into water-ways and destruction of aquatic life; composition of garbage and to the extent it is bio-degradable, and technology by which it can be reduced and disposed of, require a serious consideration. Effect of pesticides and weedicides which are used for crop protection also affect organism in the soil. All these should be addressed adequately. How to solve the problem of drinking water, various technologies used in purification of water ? Cheaper technology for obtaining good quality of drinking water. Energy, which is taken as an indicator for standard of living should be covered in a detailed way. Various renewable means of producing energy should be highlighted. 'What makes energy unusable' ?, should be discussed in relation to '*energy crisis*'. Biomass requires a special mention in relation to environment. Gobar gas plant in rural context also should be included. Conservation of mineral fuels is of utmost importance in view of their limited reservoirs.

Health and related technology require a special mention. Not only food processing but also synthesis of various food ingredients and medicines for curing diseases require serious attention. Relationship of health with environment and agriculture should be considered. Population explosion at any cost is to be checked and like many developed countries *growth rate* should come to a standstill. Technological devices to control population also require special mention.

Materials requirement and their production is another important area for *scientific literacy*. Now-a-days, synthetic materials (such as polymers, semi-conductors) are getting popularity. Materials, whether building materials or electronic materials, are of a great importance. Synthetic materials are gradually replacing natural one although they have also a potential hazard of non-biodegradability.

Many more problems are there which should be discussed in relevant places (preferably around the concepts) and relevant technology should be covered.

Science, Technology and Society (STS)

It goes without saying that science and technology jointly affect the society. Here emphasis on teaching of science and technology will be for sustainable living. After studying science and technology students should be equipped to deal with challenges and problems related to society. For this, students should be made conversant with various problems of society. They should not only think of solutions but also do in practice by identifying/designing a suitable technology. A societal problem may be solved by applying different technologies. Technology for certain problems may be local specific.

Societal needs should be determinant of the type technology should be used. Such needs may have to be given more recognition than they have been receiving up to this time. The eradication of small pox from the earth has demonstrated the potential of science and technology. Science and technology affect society but at the same time society influences the activities of scientists and technologists, creators of science and technology respectively during their planning stages and through systematic evaluation of science and technology. This interaction between science, technology and society is crucial and should be reflected in '*Science ,and Technology Curriculum*'. The increasing concern shown by the Government and industries worldwide for environmental protection is a response to pressure from society. The direction of development can be altered.

For textbook, however, some core technology or common occurring technology may be given which are considered significant and are widely available. For example, technology of manufacturing or technology of industrial processes may be covered in the books. It is not necessary to go into engineering part of it as that is not desirable at this stage. How science, technology and society are linked with each other can be illustrated by taking some suitable examples.

Example

We know N_2 and H_2 combine in presence of a catalyst

$$N_2 + 3H_2 \rightarrow 2NH_3$$

Here technology part will be how to get better yield and for that what are the conditions of temperature and pressure. Here society is getting benefit of science and technology in the form of *green revolution* and ultimately good yield and self-sufficiency in food.

Another example of STS, we can take well known nuclear reaction (fission) in case of U-235.

$${}^{235}_{92}U + {}^{1}_{0}n \rightarrow \text{nuclear products} + \text{Energy}$$

Here technology made it possible to harness this heat energy and generate electricity which serves the society.

No doubt, in both examples cited above, which relate to science, technology and society also affect the environment. Excess application of urea or radioactive rays coming out of fission reaction or even disposal of the radioactive fuel may be a potential environmental hazard. Thus, science, technology, society and environment should be considered in totality.

What is Scientific and Technological Literacy ?

In simple terms, ability to take decision and to solve problems using suitable technology is 'technological literacy' and ability to apply scientific principles in interpreting natural phenomenon and in day-to-day happenings or events in environment or in surroundings, is scientific literacy.

Technology is not 'applied science'. Technology and science grew independently in the beginning and a bond of inter-dependence came into existence at a very late stage. The technologies prior to the first industrial revolution were mainly around handicrafts. Gebhart *et al* (1979) suggested that technology is the know-how and creative process that may utilize tools, resource systems to solve problems and enhance control over the natural and man-made environment in an endeavour to improve human condition. The technology education should be able to empower learners to 'examine', 'decide', and 'select', technological solutions of contemporary issues on merit of their potential and limitations, long term consequences etc. Technology education, therefore, cannot only develop problem-solving abilities but also inculcates an element of social responsibility for using technology wisely. This becomes more meaningful in view of technological applications and its affect on our environment.

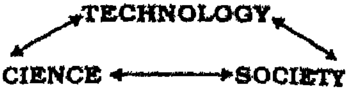
During the mechanical evolution, science and technology grew independently. Real tie between these two came after electricity was invented and much deeper closeness came during the electronic revolution as mentioned earlier.

Half-life of scientific and technological knowledge is very short. Knowledge including information is doubling after every three to four years. Technology is moving with much faster rate as compared to science. Basic scientific principles are quite stable and changes are only in their redefining or re-interpretation. There is a justification in identifying *minimum requirement of scientific principles, theories, laws which should be taught upto secondary level (science for all) to inculcate scientific temper and scientific literacy.*

Technology is basically linked with tools, devices, modelling, designs, production, simulation, etc. For example, for verifying an electrical principle, one can think of designing a circuit which is technology, for understanding bonding in molecules one can go for designing models, for measuring pH of a solution one can think of different types of devices such as taking pH' paper, measuring potential by creating a cell or by taking a more sophisticated compact device, pH' metre. In these cases, we will say: technology is different for the same objective of measuring pH of the solution

Delivery of Science and Technology

Reform in *Science education* leads to 'Science and Technology education'. Technology bridges Science and society. It is interesting to note that society was using technology even when people in society were not aware of scientific developments.



TECHNOLOGY

- ***provides approaches to problem solving***
- ***relates different subjects to life***
- ***helps to link theory and practice***

Science and Tehchnology education usually involves inter-subject teaching. For teaching 'Science and Technology' a teacher is supposed to have a broad base of scientific knowledge i.e. a teacher who is familiar with all the science disciplines (physics, chemistry, biology and mathematics). In fact such a teacher will be most successful and should be preferred. The teacher who lacks breadth in his/her science knowledge should be provided opportunity to acquire the perceived deficiency through an in-service course.

How to link technology with science is, no doubt, a challenging task. Pedagogical skills of teachers should be improved so that they are in a position to relate science and technology using examples of even *local and indigenous technology*. Further an effective science and technology teaching requires the use of variety of resources especially equipment has been regarded as an impediment in providing quality science and technology education. Many teachers fail to recognise the use of locally available and improvised materials as an opportunity to provide relevant life related science and technology education. The reason for this cynicism partly lies in the lack of their ability to identify, use and improvise suitable local materials at school level. It goes without saying that a teacher should be able to demonstrate the significance of classroom skills in relation to real life problems particularly at upper primary and secondary levels. A teacher also should know how concepts and processes are used in the industry, agriculture and commerce; some of these may be achieved through

- partnership between the world of production and community
- appropriate teaching learning instructional materials, facilities and equipment
- hand-on activities which integrate science and technology
- problem solving techniques
- consideration of the culture of scientific and technological enterprises, their values, attitude, assumptions, organisational structures and limitations.

A science and technology teacher should be encouraged to visit industries and other science and technology based establishments such as science museums, science parks, science exhibitions, science planetarium, science clubs, science centres, mobile science laboratories, local industries etc., to acquaint himself/herself with the application of science and technology principles in daily life.

Science and technology teachers must ensure that during their teaching they

- improvise, handle and demonstrate low cost teaching learning materials,
- increasingly use materials from local environment
- use improvised items made from local materials, and
- design and handle different types of apparatus and equipment.

Models are especially useful in science and technology since they enable the learner to grasp the concepts into concrete form. They can also be used to demonstrate various scientific principles in a practical way. Complexity in technological component will increase depending upon the stages (i.e. from primary to upper primary, upper primary to secondary).

In order to give a comprehensive view of science and technology, adequate quantum of information and communication technology should be integrated with teaching of science. Programme of *computer literacy* should be organized from the school stage itself. This is considered more desirable in view of rapid expansion of knowledge and great advances in science and technology.

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Buoyant Force and its Relation to the Fluid Pressure

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IN THIS article a very well known force existing in nature has been treated so as to generalise it in terms of effects of the prevalent medium and the field of force. This would in a way provide us the opportunity to see the buoyant force in a slightly different perspective. When seen in entirety it will raise some of the basic questions as well and there will be sufficient scope to understand and explain them.

This treatise on buoyant force is to explain it from the viewpoint of fluid pressure and its existence in space will enable us to treat the force equations in the way it should be. Also, it would explore this ordinary force all the time associated with objects under study whether it is static or dynamic in a noble way. It would give fair amount of insight of this natural force. Here, we gradually take up very simple cases that do not appeal too much, but appear very mundane to the students of Physics. However, when all the cases are dealt it becomes reasonably interesting.

While going into the detailed analysis of the buoyant force and its connection to the fluid pressures, it will be worthwhile to state the buoyant force that originated from the important principle stated by Archimedes named after him as Archimede's principle. "An upward thrust, which arises due to displacement of fluid, is of the same magnitude as that of the weight of the displaced fluid".

Now, the very first question about the direction, which is upward, can simply be understood from the fluid pressure relationship. As mentioned earlier we take up simpler cases first.

Parallelepiped or Cuboid

Consider parallelepiped of height h and topside cross-sectional area A existing in fluid of density d then the displaced liquid will tend to occupy the volume of the parallelepiped, the direction along which fluid will rush will be normal to the surface area. If the pressure on the upward surface is p then the pressure on the bottom side cross-sectional area is $p+hdg$ in the earth's field (Fig.1)

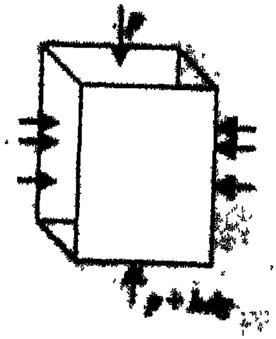

Fig. 1

The lateral face pressures at each level are equal and opposite cancelling out without giving rise to any excess force in the horizontal direction. But the vertical forces or thrust on the surfaces are unequal but opposite in direction, giving rise to an excess force called the buoyant force (B) opposite in direction to the gravitational force.

Calculation is simple and can be given as

$B = [(p+hdg)-p]A = Ahdg$

$B = Vdg$; where $V = Ah$ is the volume of the parallelepiped.

Regular Cylinder

In this case also the same conditions are observed when assumed to be existing in a fluid of density d. The lateral curved surface have equal pressures from both the sides and this pressure is equal and opposite so each horizontal force is cancelled by the diametrically opposite force (Fig.2). As a result there is no excess force in the horizontal direction. Where as the top side and the bottom side thrusts are different in magnitude due to the variation of the vertical height h and the consequent pressure. The resultant is a net upward thrust B, the buoyant force, given by $B = [(p + hdg) - p] A = Ahdg = Vdg$ where A is the circular cross-sectional area of the cylinder.

Sphere

In case of sphere, the fluid rushes to seek the centre in a direction normal to the surface area. Fig. 3 clearly shows that the resultant direction of the force acting is different in the upper hemisphere and the lower hemisphere. The horizontal components at each level for this case also cancel out in diametrically opposite pairs. While the lower hemisphere gives a resultant upward force, the upper hemisphere has a resultant downward force. Now, we take up the calculation of the buoyant force on the same footing but only divide in two parts to show the magnitudes of the upward and downward forces.

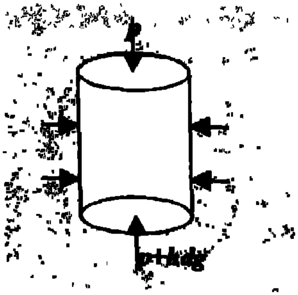

Fig. 2

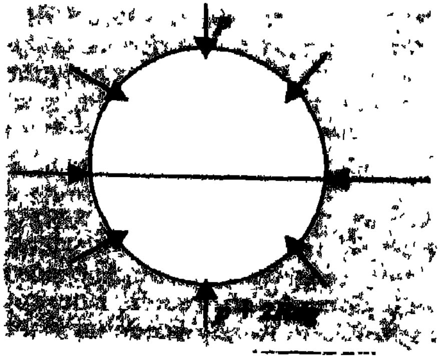

Fig. 3

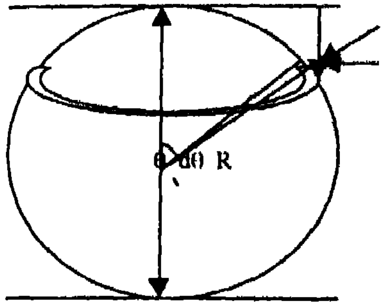

Fig. 4

Consider Fig. 4 which represents an elementary annular ring with an angular measure in between θ and θ + dθ. the width of the ring is R dθ, the surface area dA of the ring is 2πR² sinθ dθ, the vertical component of the hydrostatic pressure is *hdg*, where *h* is the height below the topside tangent as the horizontal components cancel out in pairs. Thus the vertical components would sum up to give the net force in the vertical direction. While treating the entire surface of the sphere we just separate out the hemispherical contributions. As may be seen after the whole exercise that the buoyant *B* force just comes out in the simple form of *Vdg* as a difference of the lower and upper hemispherical contributions.

$$dA = 2\pi R^2 \sin\theta . d\theta$$

$$d\dot{F} = \dot{P}.\dot{n}dA = hdg(\cos\theta)2\pi R^2 \sin\theta . d\theta \quad ...(1)$$

$$= 2\pi R^4 hdg \cos\theta \sin\theta . d\theta$$

$$\cos\theta = \left[1 - \frac{h}{R}\right]$$

$$h = R(1-\cos\theta) \quad ...(2)$$

$$\int_0^{\pi/2} dF = \int_0^{\pi/2} 2\pi R^2 hdg \cos\theta \sin\theta . d\theta$$

$$\text{or} \int_0^{\pi/2} F_d = 2\pi R^3 dg \int_0^{\pi/2} (1-\cos\theta)\cos\theta \sin\theta . d\theta$$

Integrating, we get $F_d = \frac{\pi}{3} R^3 dg \quad ...(3)$

For calculating upward forces

$$h = R + R\cos\theta$$

$$F_u = 2\pi R^3 dg \int_0^{\pi/2} (1+\cos\theta)\cos\theta \sin\theta . d\theta$$

Which on integrating gives

$$F_u = \frac{5\pi}{3} R^3 dg \quad ...(4)$$

The resultant upward forces

$$F_R = F_u - F_d = \frac{4}{3}\pi\ {}^3dg$$

So, ultimately we get the same simple form of the Buoyant force **B = Vdg** for the sphere in the upward direction. Only clarity obtained here is the Buoyant force has assumed the upward direction.

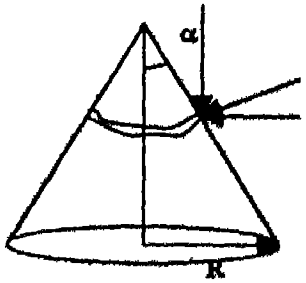

Fig. 5

Right Cone

In case of a cone we are faced with a similar situation and the forces are also different but gives the same Buoyant force as the resultant. Considering a cone of circular cross-sectional area of πR^2 and height H, having vertical angle α then the force can be easily calculated for obtaining the general form of Buoyant force in terms of fluid pressure as follows :

The curved surface of the cone is given by

$$ds = 2\pi R\cos ec\alpha.dR$$

$$dF = 2\pi RhdgdR$$

$$= 2\pi R^2dg\cot\alpha.dR$$

$$F = \int_0^R 2\pi R^2dg\cot\alpha.dR$$

$$= (2\pi dg\cot\alpha)\frac{R^3}{3}$$

$$= \frac{2\pi R^2dgH}{3}$$

Net upward force can be calculated as

$$= \pi R^2dgH - \frac{2\pi R^2dgH}{3}$$

$$= \frac{\pi R^2dgH}{3}$$

$$= Vdg$$

Here the downward force on the apex side of the cone is equal to

$$= \frac{2\pi R^2dgH}{3}$$

The buoyant force calculation from the fluid pressure obviously has given the direction clearly for the resultant buoyant force. This is obtained as an upward force opposite to the gravitational field of the force. Treating buoyant force in this way in an inhomogeneous medium and field of force will enable us to calculate the exact magnitude of the buoyant force due to displacement of liquid numerically with the direction. This will also help in framing force equations.

Apart from these, some issues that are raised while treating the entire problem of hydrostatic pressure at a given level due to the fluid coloumn pressure, need due interpretation as per actual case. It also shows that the horizontal and vertical components are not equal. How then this be explained using Pascal's law ? The hydrostatic pressure at a given level of fluid column hdg is the vertical direction.

Most importantly, this method is more explicit and suggests that the body movements of the swimmers can be treated technically so as to make exact movements to gain the effect of unbalanced buoyant force in hydrostatically unequilibrium stages. There is another very important application possible in the field of navigation. The design of ships and submarines need various shapes and placement of weights, which could be done by knowing exact buoyant force. Shaping and placement of weights can be done properly for effective motion.

The Origin of Elements

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THE UNIVERSE is made up of elements from Hydrogen to Uranium. How did these elements originate ? What primordial stuff they are made of ? The Universe is composed of largely hydrogen and helium. 76% by weight of Universe matter is made of Hydrogen, 23% by weight of helium. All other elements taken together constitute 1%. Further, the iron group of elements is 10000 times more abundant than their neighbours (Fig. 1). Why elements in the vicinity of mass number 56 abundant ? The most powerful clues to these bewildering questions comes from the study of relative abundance of various elements in our universe i.e., from the study of composition of, (1) the crust, oceans, atmosphere of our planet, (2) meteorites from the outer space, (3) light from stars and

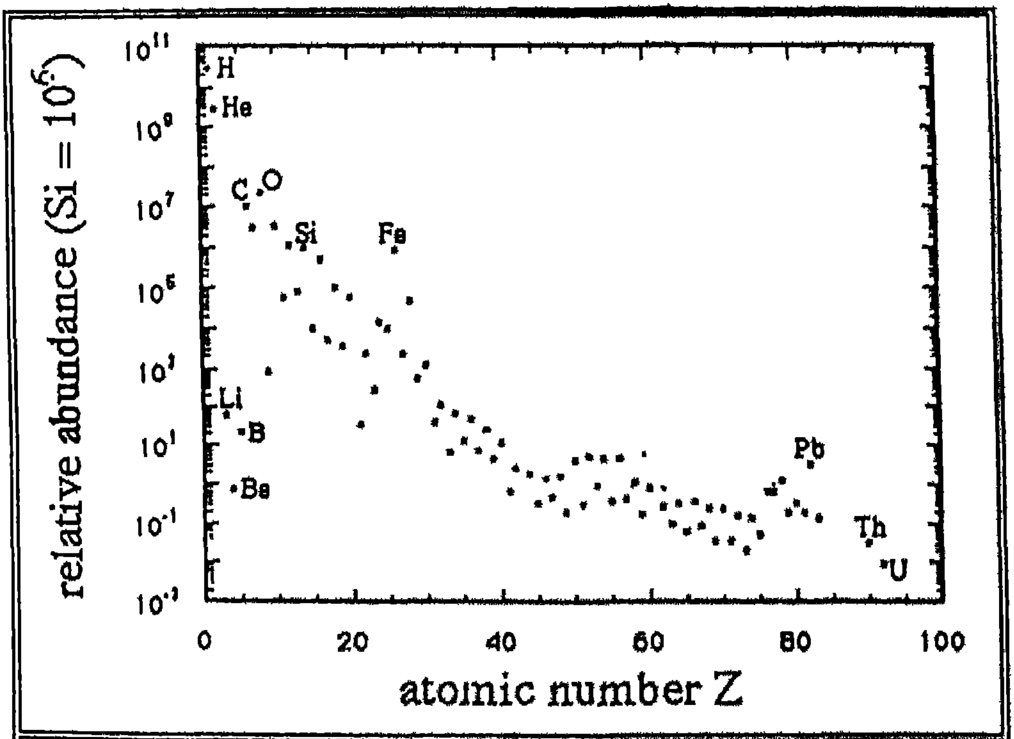

Figure 12: Relative abundance of elements

Fig. 1

(4) cosmic ray from space. These studies reveal an intimate connection between the cosmic events that followed the "big bang", the life story of stars and the origin of elements.

Today we know that all these are made up of neutrons and protons. But how the protons and neutrons themselves were created is not known, but these may be taken up as starting material for working hypothesis. It is believed that these were formed in sequence of events (Fig. 2) according to George Gamow.

Gamow's theory

Gamow and his collaborators believed that the core of super hot and super dense materials, which exploded, was made of neutrons because under the great pressure electrons could be compressed into protons. Small portion of neutrons might have split over into protons and electrons following the explosion of the core and consequent expansions. Each of the protons so formed might have captured neutrons step by step.

Supposed Sequence of Events

Explosion of the space (15-20) billion years ago) (Super dense, super hot material) cause not known

↓ *1/100th s*

T = 100 billion degrees.
Matter rushing apart are elementary particles as electrons, protons, neutrinos and possibly a few protons and neutrons

↓ *1/10th s*

T = 30 billion degrees (cooling due to expansion)

↓ *1s*

T = 10 billion degrees

↓ *3 min.*

T = 1.0 billion degrees (protons and neutrons might have combined to form simple nuclei as D and He)

Many thousand years ↓

Cool enough for electrons and protons to join nuclei to form neutrons, protons and even atoms of hydrogen.

↓ *5 billion years*

Clumps under the influence of gravitation to form galaxies and stars made up of hydrogen, neutrons and protons

Fig. 2

$${}^{1}_{1}H + {}^{1}_{0}n \longrightarrow {}^{2}_{1}D + {}^{1}_{0}n \longrightarrow {}^{3}_{1}H \xrightarrow{-e} {}^{3}_{2}He + {}^{1}_{0}n \longrightarrow {}^{4}_{2}He \longrightarrow \longrightarrow \longrightarrow$$

By rapid succession of neutrons capture and electrons decays, all elements were formed in the first burst of Universe's expansion within a few minutes. Such neutron capture scheme appeared probable because of non-existence energy barrier. Laboratory experiments supported such a view by the fact that all nuclei's are capable of capturing neutrons readily, and more importantly, neutron capture cross section of the various nuclei predict a pattern of elements abundance which agrees remarkably well with the one actually observed. It rises sharply up to mass No. 100 as the nuclear cross section is small i.e. the rate at which neutron is observed is very low and hence greater abundance as they are not converted readily into other elements.

The theory became popular but was not completely satisfactory — the most serious defect was that stable atoms with mass numbers 5 and 8 are not known. Laboratory experiments have shown their momentary existences (helium-5 decays to helium-4 and beryllium 8 breaks into two helium atoms). Therefore, the chain should break. Then how can the build up of elements by neutron capture get by these gaps ?

Bethe's theory

In 1938, H.A. Bethe *et al.* proposed that the elements were built not in a primordial explosion but in the hot interior of stars consisting of protons. A star is believed to be formed when large dense inter steller clouds of gas, largely hydrogen, contracts (reason for contraction is fully understood). Once the cloud is formed, further contraction takes place due to gravitational force leading to increase in pressure and temperature. When the temperature reaches 5 million degree nuclear fusion reaction is triggered and protons get fused together to form helium nuclei.

$${}^{1}_{1}H + {}^{1}_{1}H \longrightarrow {}^{2}_{1}D + {}^{0}_{+1}e + h\nu$$

$${}^{2}_{1}D + {}^{1}_{1}H \longrightarrow {}^{3}_{2}He + h\nu$$

$${}^{3}_{2}He + {}^{3}_{2}He \longrightarrow {}^{4}_{2}He + 2\,{}^{1}_{1}H + h\nu$$

The Coulomb barrier for the first step in the chain is about 0.5 MeV. At the centre of our sun, the temperature is approximately 15×10^{6}K. Therefore, the mean thermal kinetic energy of a nucleus at the centre is $3/2\ RT_c \approx 2$ KeV. Under such conditions classical physics says that two hydrogen nuclei can never get close enough for a nuclear reaction to occur. But quantum mechanics predicts that there is a finite probability (tunneling effect) for two nuclei to come close enough to fuse together to form a heavier nuclei. In the

Life Story of a Star

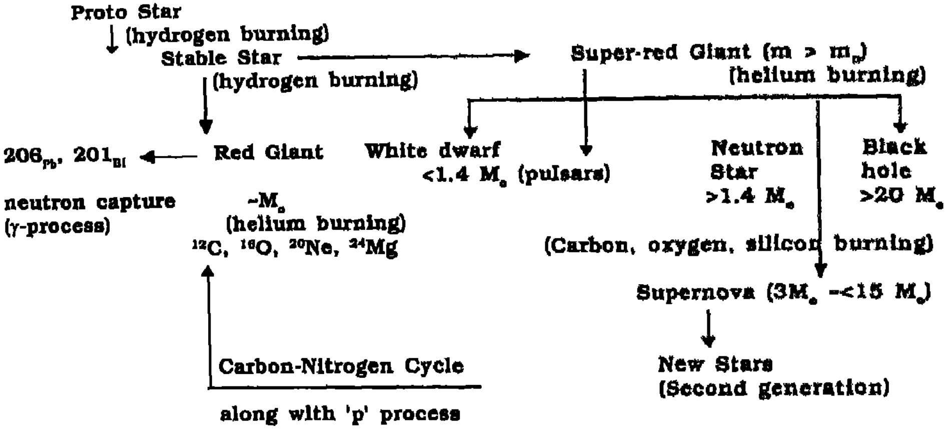

Fig. 3

process, a huge amount of energy gets released and that is why a star shines. A star at this stage is known as a protostar. As the hydrogen nuclei fuse together in the interior of the cloud where temperature become too high due to extremely high pressure the energy released due to fusion travels to the surface of the stars, and gets radiated in the form of heat, light and other electromagnetic radiation. The release of energy creates an outward force that balances the inward gravitational force in the star. Contraction stops when outward force balances the gravitational force and the star becomes stable in size and temperature. Such a star is known as a stable star. Sun has been in this stable condition for the past five billion years though it is utilizing 400 million tons of hydrogen in every second. Greater the mass of the star, lower the temperature at which it becomes stable. 80% of the stars are now in their stable state (main sequence). Bigger stars burn their fuel much faster and comparatively stay for a shorter period in the main sequence (The period in the main sequence for a star with a mass as that of the sun M_0 is of the order of 10 billion years; a star with a mass of $15M_0$ is of the order of 10 million years; a star with a mass of $0.25M_0$ is of the order of 70 billion years). The sun will remain in its present stable state for another five billion years and will continue to shine.

When a large portion of the fuel (hydrogen) in the core of a star gets utilised, nuclear reactions become slow, outward force reduces and the gravitational pull results in further contraction. As a consequence, the temperature begins to rise once again. The fusion of hydrogen continues in the outer layer of the shell surrounding the core. The heat generated along with the heat from the core causes the star to boil like a liquid and expand. The star becomes big and brightness increases. But as the outer layer expands further away from the core its temperature falls. The puffed up star looks red and cool. The star in this stage is known as a *red giant*. In this stage, the life span is short, hydrogen is consumed very fast piling up helium in its core. When all hydrogen is used up the star begins to cool. Contraction again takes place due to gravitation and temperature rises to hundred million degrees sufficient enough to trigger fusion of helium nuclei to form nuclei of higher mass numbers.

$$ {}^{4}_{2}\mathrm{He} + {}^{4}_{2}\mathrm{He} + {}^{4}_{2}\mathrm{He} \longrightarrow {}^{12}_{6}\mathrm{C} $$

Laboratory experiments have shown that C^{12} obtained by bombarding boron with deuterium disintegrates into three helium nuclei. So the reverse process can take place in the hot core of the star (Hoyle).

$$ {}^{4}_{2}\mathrm{He} + {}^{4}_{2}\mathrm{He} \longrightarrow {}^{8}_{4}\mathrm{C} $$

But it is unlikely as nuclei with mass numer 8 is extremely unstable (half life = 2×10^{-16}s) and disintegrates as fast as it is formed. But there is a probability of occassional existence and combining with another helium nuclei to form C^{12}.

$$ {}^{8}_{4}\mathrm{Be} + {}^{4}_{2}\mathrm{He} \longrightarrow {}^{12}_{8}\mathrm{C} $$

This jump from helium to carbon skips the elements Li, Be and B which are comparatively rare and are formed by secondary processes. It is known, for instance, that bombardment of heavy elements with hydrogen nuclei sometimes chips off fragments which are identifiable as nuclei of Li, Be, B — possibly this process goes on the surface of stars, known as *Sun spots*.

Once C^{12} has been synthesized in the core of a helium star, it may build up, by successive captures of helium nuclei, the nuclei of oxygen 16, neon 20 and possibly magnesium 24.

$$ C^{12} \longrightarrow O^{16} \longrightarrow Ne^{20} \longrightarrow Mg^{24} $$

Fusion of helium nuclei proceeds in the stellar core until all helium is converted into C^{12} and O^{16}. Then there are two possibilities for the star. If the mass is low, the core does not contract enough for its temperature to rise enough to trigger further fusion of carbon nuclei. Such stars quietly end their lives as white dwarfs. In 1930, Chandrasekhar showed that such stars are supported against gravitational collapse by electron degeneracy pressure if their masses are $1.4M_0$ or less (Chandrasekhar limit).

More massive stars do not end their live in this way. Contraction of the core raises its temperature as high as 5×10^{8} to 1×10^{9} K and trigger interaction among carbon, oxygen and neon, producing nuclei of elements of silicon group, (around mass 28). When the temperature of the core reaches five billion degrees, fusion of nuclei results in the synthesis of the most stable elements, namely iron and its neighbours (at mass 56).

$$ \left.\begin{array}{l} C^{12} + C^{12} \longrightarrow Ne^{20},\ Mg^{24} \\ O^{16} + O^{16} \longrightarrow Si^{28},\ S^{32} \end{array}\right] 1 \times 10^{9}\mathrm{K} $$

$$ C^{12} + O^{16} \longrightarrow Si^{28} $$

$Si^{28} + Si^{28} \longrightarrow Fe^{56}$ Coulomb barrier requires a temperature of 5×10^{9}K.

$$\left.\begin{array}{l} Si^{28} + {}^{4}_{2}He \longrightarrow S^{32} + \gamma \\ Si^{28} + \gamma \longrightarrow Mg^{24} + {}^{4}_{2}He \end{array}\right] \text{Photodisintigeration reaction}$$

Once the core of the star is converted into iron group of nuclei, the star nearly reached its end of life as no further energy generating reactions are possible (the binding energies of the iron groups elements is highest). The chain of the fusion stops as the collapse occurs, the density grows until it becomes energetically favourable for electrons to combine with protons produced by protodisintegration reactions and produce neutrons and neutrino. This neutronies the core of the star and produces a huge burst of neutrino and ultimate explosion. The mantle is blown off leaving behind a neutronised remnant. If the mass of the remnant is less than 2-3M_0 it becomes a neutron star *(pulsars)*. More massive (20M_0) stars are believed to continue to collapse and form Black Holes. Due to very high gravitational force black holes do not allow even light to escape. Stars with mass between 3M_0 to 15M_0 often explode as nova or supernova releasing tremendous amount of energy. In a super nova explosion, the whole star is disrrupted and it is very uncertain, whether what remains will be a neutron star, a black hole or simply disintegrate as stellar debris.

The debris of matter from such explosions pours into space which mixes with interstellar gas (largely hydrogen) which may condense to form new stars, called second generation stars having elements up to iron group in their cores. Existence of young infant stars in our galaxy is a strong evidence.

In these stars, hydrogen in the core is again converted to helium but because of the presence of carbon, the conversions take place through a different route, known as the carbon-nitrogen cycle.

$${}^{12}_{6}C + {}^{1}_{1}H = \longrightarrow {}^{13}_{7}N + h\nu$$

$${}^{13}_{7}N \xrightarrow[10.1m]{t_{1/2}} {}^{13}_{6}C + {}^{0}_{+1}e$$

$${}^{13}_{6}C + {}^{1}_{1}H \longrightarrow {}^{14}_{7}N + h\nu$$

$${}^{14}_{7}N + {}^{1}_{1}H = \longrightarrow {}^{15}_{8}O + h\nu$$

$${}^{15}_{8}O \xrightarrow[2.05m]{t_{1/2}} {}^{15}_{7}N + {}^{0}_{+1}e$$

$${}^{17}_{5}N + {}^{1}_{1}H = \longrightarrow {}^{12}_{6}C + {}^{4}_{2}He$$

$$4\,{}^{1}_{1}H \longrightarrow {}^{4}_{2}He + 2 + {}^{0}_{+1}e + h\nu$$

This chain reaction is the source of energy in second generation stars and the temperatures may go up to 15 million degrees.

Origin of Heavy Elements (A>56)

The oxygen, carbon and neon present in the second generation stars are converted by proton capture to O^{17}, C^{14}, Ne^{21}, etc. These isotopes play a crucial role when the star enters the red giant stage with a core consisting of hot helium. The three isotopes react with helium to produce unstable nuclei which emit neutrons.

$$^{13}_{6}C + {}^{4}_{2}He \longrightarrow {}^{16}_{8}O + {}^{1}_{0}n$$

$$^{17}_{8}C + {}^{4}_{2}He \longrightarrow {}^{20}_{10}Ne + {}^{1}_{0}n$$

$$^{21}_{10}C + {}^{4}_{2}He \longrightarrow {}^{24}_{12}Mg + {}^{1}_{0}n$$

As all nucleis are capable of capturing neutrons including iron group of elements, successive capture of neutrons, generated in the above processes, all nucleis can be built up upto elements as heavy as lead and bismuth.The procecess terminates at ^{209}Bi as ^{210}Bi is radioactive.

It is believed that during a supernova explosion, conditions of high temperature and density are favourable for the heavy elements to capture neutrons and continue the chain even beyond bismuth. Detection of an isotope of the element californium in the debris from a thermonuclear explosion (1952, Bikns test) and discovery of the unstable element technetium provides confirmation of such a view.

Many cosmic events preceded the formation of earth. The oldest star in our galaxy is estimated to be 6.5 billion years old. Our solar system is no more than 4.5 billion years old. The big-bang occurred about 15 billion years ago.

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Some Methods to Find Cube Root

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Introduction

THE 'Lilavati' well known treatise of mathematics originally written in the form of Sanskrit verses were in vogue in India upto the medieval period to solve and learn mathematical problems related to Number Systems, Geometry, Mensuration etc. The procedure to find cube root of a number is given in *sloka* 14-15 of 'Ghane-Karan Sutram Vrit-triyam of Lilavati'. In this paper this procedure is simplified to find cube root upto three digits and elaborated with some illustrations. We present few more illustrations to find cube root which are based on other ancient Hindu texts and generalise the result for bigger numbers.

Preliminaries

(a). As it is known that first nine natural numbers have last digits in their cubes 1, 8, 7, 4, 5, 6, 3, 2, 9 respectively which can be seen in the manner that all perfect cubic numbers ending with digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 have the last digit in their cube roots 0, 1, 8, 7, 4, 5, 6, 3, 2, 9 respectively.

(b). The number of digits in the cube root of any number depends on the total group of triplets of digits taken from right to left. The number of digits in the last group towards left may be one, two or three depending upon the value of number e.g. 1953 125 has three digits in its cube root, because it has three group of digits.

(c). First digit of cube root of any number may be recognised by the first group of digits towards left as in the cube root of 54 872 the first digit will be 3 because the value nearer to 54 is the cube of 3 i.e. 27.

(d). The cube of any three digit number can be expanded as :

$$(100x + 10y + z)^3 = 1000000x^3 + 300000x^2y + 30000\,(xy^2 + x^2z) + 1000\,(y^3 + 6xyz) + 300\,(xz^2 + zy^2) + 30\,yz^2 + z^3$$

which may be analysed further in the following manner :

i. digit at the unit place is z^3
ii. digit at ten's place is $3\,z^2y$
iii. digit at hundred's place is $3(xz^2 + zy^2)$
iv. digit t thousand's place is $y^3 + 6xyz$
v. digit at ten thousand's place is $3(x^2zy + y^2x)$
vi. digit at lakh's place is $3x^2y$
vii. digit at ten lakh's place is x^3

The above expansion may also be generalised for numbers having more than three digits.

(e). The procedure to find cube-root given in *sloka* 14-15 of Lilavati has the first step for assigning the digit from right to left at cubic and non-cubic places by taking one digit at cubic place and next two at non-cubic place, proceeding in same way upto the last digit.

Results

To find cube root upto three digits we follow the following algorithm in which first step is similar to preliminaries (e) and other steps are simplified for easier solution.

Step 1 : First we assign the cubic and non cubic places to the digits of given number e.g. $5\ \overset{1}{4}\ 8\ 7\ \overset{1}{2}$ in which the digits 2 and 4 are at cubic place and digits 7, 8, 5 at non cubic place which are symbolised by 1 and respectively

Step 2 : To determine the number of digits in the cube root of any given number we form the group of triplets of digits from right to left as defined in preliminaries (b) e.g. 5 4 8 7 2 has two groups, so total digits in its cube root are two.

Step 3 : To determine the last digit of cube root we use the notion as given in preliminaries (a) and denote it by X e.g. for the number 54872 the last digit of its cube root will be 8.

Step 4 : To simplify the method as given in (1) we take the digits from extreme left to that digit at cubic place which leave two digits at non cubic place and one digit at cubic place towards right e.g. in $5\ \overset{1}{4}\ 8\ 7\ \overset{1}{2}$, we take 54 leaving two digits 8 and 7 at non cubic place and 2 at cubic place towards right. To determine the first digit of cube root, we can recognise the digit/number whose cube will be nearest to smaller or equal to it by inspection and denote it by Y and subtract cube of Y from given number from left e.g. in $5\ \overset{1}{4}\ 8\ 7\ \overset{1}{2}$, the first digit in its cube root will be 3.

Step 5 : Now we take square of the first digit as obtained from step 4, multiply it by 3 and further multiply it by the last digit of cube root as obtained from step 3 and subtract this value from the number obtained at step 4 from left.

Step 6 : We take square of the last digit of cube root, multiply it by the first digit of cube root and further multiply it by 3 and subtract this value from the number obtained at step 5 from left.

Step 7 : We take cube of the last digit (X), subtract it from the number obtained at step 6 making the difference zero.

Step 8 Hence the cube root of given number is YX.

Illustration 1

Let given number be 5 4 8 7 2.

We follow the algorithm stepwise as given in the previous section results.

Step 1 : $5\ \overset{1}{4}\ 8\ 7\ \overset{1}{2}$

Step 2 : $5\ 4\ \underline{8\,7\,2}$ (total digits in its cube root two)

Step 3 : The last digit of given number is 2 So using the notion of preliminaries (a), the last digit of its cube root will be 8.

Step 4 : $5\ \overset{1}{4}\ 8\ 7\ \overset{1}{2}$, we take 54 leaving two digits 8, 7 at non cubic place and digit 2 at cubic place towards right. By inspection first digit of its cube root will be 3 because $3^3 = 27$ and $4^3 = 64$ (greater value)

$$\begin{array}{r} \underline{5\ 4\ 8\ 7\ 2} \\ -\ \underline{2\ 7} \\ 2\ 7\ 8\ 7\ 2 \end{array}$$

Step 5 : $3^2 = 9$; $9 \times 3 = 27$; $27 \times 8 = 216$

$$\begin{array}{l} 27872 \\ \underline{216} \\ \ \ 6272 \end{array}$$

Step 6 : $8^2 = 64$; $64 \times 3 = 192$; $192 \times 3 = 576$

$$\begin{array}{l} 6272 \\ \underline{576} \\ \ \ 512 \end{array}$$

Step 7 : $8^3 = 512$

$$\begin{array}{l} 512 \\ \underline{512} \\ \ \underline{\times} \end{array}$$

Step 8 : Cube root of given number is 38.

Illustration 2

Let given number be 1953125

Step 1 : $\overset{|}{\bar{1}}\ \bar{9}\ \bar{5}\ \overset{1}{\bar{3}}\ \bar{1}\ \bar{2}\ \overset{1}{\bar{5}}$

Step 2 : $1\ \underline{9\ 5\ 3}\ \underline{1\ 2\ 5}$ (total digits in its cube root are three)

Step 3 : The last digit of given number is 5, so last digit of its cube root will be 5.

Step 4 : We take 1953 leaving behind two digits at non-cubic place and one at cubic place. By inspection $12^3 = 1728$ is nearest smaller value to 1953

$$\begin{array}{l} 1\ 9\ 5\ 3\ 1\ 2\ 5 \\ \underline{1\ 7\ 2\ 8} \\ \ \ 2\ 2\ 5\ 1\ 2\ 5 \end{array}$$

Step 5 : $12^2 = 144$, $144 \times 3 = 432$, $432 \times 5 = 2160$

$$\begin{array}{l} 2\ 2\ 5\ 1\ 2\ 5 \\ \underline{2\ 1\ 6\ 0} \\ \ \ \ \ 9\ 1\ 2\ 5 \end{array}$$

Step 6 : $5^2 = 25$; $25 \times 3 = 75$; $75 \times 12 = 900$

$$\begin{array}{l} 9\ 1\ 2\ 5 \\ \underline{9\ 0\ 0} \\ \ \ 1\ 2\ 5 \end{array}$$

Step 7 : $5^3 = 125$

$$\begin{array}{r} 125 \\ -\ \underline{125} \\ \underline{\times} \end{array}$$

Step 8 : Hence cube root of given number is 125.

Result

Another method to find cube root as explained in (2) is given below to find cube root upto three digits or more.

Illustration 3

Let given number be 679151439

Step 1 : $\underline{6\ 7\ 9}\ \underline{1\ 5\ 1}\ \underline{4\ 3\ 9}$ (total digit in its cube root are three)

Step 2 : last digit of given number is 9, so last digit in its cube root must be 9 denote it by z.

Step 3 : The extreme left triplet of digits is 679 which is nearer to cube of 8, so first digit in its cube root is 8, denote it by x.

Step 4 : Now we follow the process of elimination as mentioned in preliminaries (d) to find the ten's place digit of cube root. To eliminate the digit at unit's place, we subtract z^3 from given number.

$$\begin{array}{rrr} 679 & 151 & 439 \\ \underline{} & \underline{-} & \underline{729} \\ \underline{679} & \underline{150} & \underline{71^*} \end{array}$$

Step 5 : To eliminate the digit at ten's place we subtract $3yz^2$ from the number obtained at step 4, here, $z = 9$, $3yz^2 =$

$3y(9)^2 = 243$. by inspection, we observe the value of y as this product 243y must have last digit 1 so y = 7 therefore 243 × 7 = 1701

67915071
1701
6791337*

Now no need to proceed further as all the digits of its cube root are obtained and its cube root is 879.

Illustration 4

Let given number be 41673648563

Step 1 : 41 673 648 563 (total digits in its cube root are four)

Step 2 : Last digit of given number is three, so last digit of its cube root will be 7 (unit's place) say z.

Step 3 : The extreme left group of digits has the value 41 which is nearer to the cube of 3. so first digit of its cube root will be 3, (say w).

Step 4 : Now we follow the process of elimination to find the other digits of its cube root. To eliminate the digit at unit's place of given number we subtract z^3 from it.

$z = 7$; $z^3 = 7^3 =$ 343
41 673 648 563
343
41 673 648 22*

Step 5 : To eliminate the digit at ten's place, we subtract

$3yz^2$; here $z = 7$ $3\,yz^2 = 147y$ by inspection, we observe the value of y, as the value of 147y must have the last digit 2. so y = 6

$3\,yz2 = 147 \times 6 = 882$
41 673 648 22
8 82
41 673 639 4 *

Step 6 : To eliminate the digit at hundred's place, we subtract $3\,zy^2 + x\,xz^2$

here $z = 7$, $y = 6$,
$3zy^2 + 3xz^2 = 756 + 147x$

Now we observe the value of x as 756 + 147x must have last digit 4, so x - 4 and

$3zy^2 + 3xz^2 = 1344$
41673639 4
1344
41673505*

As we have obtained all the four digits of cube root, so no need to proceed further and the cube root of given number is 3467.

This method is useful to obtain the cube root of bigger numbers by using the suitable process of elimination and the expansion may be done accordingly as given in preliminaries (d).

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He Placed India on the Nuclear Map of the World

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As is well-known many of our industrialists prefer "foreign collaboration" to developing what they want indigenously. This is both due to lack of self-confidence and the prestige that the name of a collaborating firm belonging to an advanced nation brings. But paradoxically, the two fields in which India is widely respected for its achievements are Nuclear Energy and Space Technology, in which foreign collaboration was totally denied to us or was minimal. In fact, powerful nations have gone to the extent of even preventing others from helping us in these fields. But this very fact led to us being thrown back on our own devices and our scientists and engineers rose to the challenge. Truly there can be no greater spur than adversity !

The man who played the major part in inducting India into nuclear club was Dr Homi Jehangir Bhabha, distinguished scientist and the first Chairman of our Atomic Energy Commission (AEC). Scion of a rich and well-connected family, he could have spent his life in ease and comfort, but chose to dedicate himself to strengthening his country. His tragic death in an air crash at the peak of his powers prevented him (and his country) from realizing his full potential.

Bhabha was born into a wealthy Parsee family of Bombay on 30 October 1909. Access to good books and contacts with distinguished public figures came easily to him through the stature of his family. The political and economic nationalism of leaders like the Nehrus and Tatas, frequent visitors to his home, inspired in him the desire to see his country the equal of advanced nations in technology. He was to devote his life to this dream.

Bhabha was gifted with great versatility. His tastes ranged from science to music to painting. In fact, he had to consciously concentrate his efforts in his chosen field and relegate the other interests to mere hobbies in order to achieve success. Modern science and technology are far too developed and demanding to accommodate current versions of universal geniuses like Leonardo da Vinci !

After his basic studies in Bombay, Bhabha entered Caius College in Cambridge University in 1927 to study engineering. He obtained the Mechanical Sciences Tripos in 1930. This training in engineering was to be of immense help to him when he later shouldered the responsibility of building up India's nuclear establishment.

But this period, the 1930's was an exciting period in physics. The secrets of the atom were being unravelled by brilliant scientists like Niels Bohr, Otto Hahn, Enrico Fermi and many others while their colleagues like Erwin Schroedinger, de Broglie and others were developing the Quantum Theory. Physics was in a great state of flux and a gifted young mind like Bhabha's could hardly remain unaffected. He enthusiastically plunged into research work on Cosmic Rays. His work was to prove an important contribution to this field. He published his first paper in October 1933. He developed, in collaboration with W. Heitler, a German physicist, the Cascade Theory of Cosmic Rays. This theory explained how cosmic rays, originating from far-away sources in space interact with the nuclei of the atoms of our atmosphere and release a secondary shower of electrons, which then repeat the process in a cascading fashion until the energy of the cosmic rays is dissipated. This work brought Bhabha to the attention of the scientific world.

But this did not fully explain the phenomenon of cosmic rays. It was known that a portion of the cosmic rays penetrated deep into sea water too. Hence in a further work Bhabha proposed the concept of 'heavy electrons' with a mass of one hudred times the normal electron, present in cosmic rays and which had the power to penetrate right through the atmosphere into the oceans. This was later experimentally confirmed and proved to be one of the best proofs for Einstein's Theory of Relativity. Even apart from his contributions to building up the Indian Nuclear Energy establishment, Bhabha's achievements as a scientist would have earned him a permanent name.

In spite of the congenial atmosphere for work in the West and his own achievements, Bhabha had no intention of settling there permanently. The desire to raise his country to the technological level of the West burned in him deeply. He felt that India would never command respect in the world unless this was achieved.

With a variety of interests to keep him engaged Bhabha was never in danger of being idle or bored. In fact, so great was his thirst to satisfy his interests that he decided to avoid matrimony, with all its demands on time and attention.

Bhabha returned to India in 1939 and took up the post of Reader in Indian Institute of Science, Bangalore. Two years later he became Professor of cosmic ray research. In 1941, he was elected a member of the Royal Society of London.

It was Bhabha's belief that a nation can get a steady stream of top grade scientists only if it had institutions devoted to attracting and nurturing gifted research workers (the Max Planck Institutes of Germany, for example, play that role for their nation). Hence he persuaded the Tata family to found the Tata Institute of Fundamental Research (TIFR) today recognized as a world class research organization. Bhabha became its first Director in 1945.

India's independence in August 1947 marked a watershed for scientific research in this country. Instead of a colonial regime reluctant to see India progress, the new set of indigeneous rulers were positively raring to see Indian science and technology grow. Pandit Jawaharlal Nehru, who symbolized this trend best asked Bhabha to become the first Chairman of India's Atomic Energy Commission, founded in 1948. Hereafter, Bhabha's role was to be more of an administrator and builder of institutions.

Bhabha was emotionally so much involved with the institutions that he built up that he took part in every aspect of their planning, right down to the design of the gardens. Starting with the experimental APSARA reactor commissioned in August 1956 progress was swift, leading to the establishment power generating reactors in Trombay and Kalpakkam.

In staffing these institutions Bhabha took care to see that he did not bleed other institutions of their prized staff. He got his staff mainly from Indians studying or working abroad. Though an epitome of self-confidence he was modest enough to yield to the majority opinion of his co-scientists when it went against him.

Bhabha's services were much appreciated even during his life time. He was awarded the Padma Bhushan in 1954 and countless honorary doctorates. But the most satisfying of all was a purely informal title the people of the nation gave him: Father of Nuclear Energy in India. But the nation was not destined to benefit for too long from Bhabha's services. At the peak of his powers, at the age of only 56, Bhabha died in a tragic air accident on 24 January, 1966 in France.

Today India is recognized as the leader among developing nations in the field of Nuclear Energy applications. Our nuclear weapons programmes too depend on the solid bedrock of infrastructure and trained personnel that Bhabha built up. This is the most enduring legacy of Bhabha and the fulfilment of his dream.

A Study of Teacher's Understanding of Basic Concepts of Physics

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DURING the last few decades, there has been much interest in the study of student's alternative frameworks. Many studies have been undertaken for this purpose. (For a review of such studies, see for example Driver *et al.* 1985, Mc Dermott 1984, Novak 1987, Saxena 1994.) Attempts have also been made to identify the origin of the alternative frameworks among students. These include misinterpreted kinaesthetic experience, linguistic interference (Solomon 1983), wrong interpretation (Riet and Alen 1992) due to disconnected knowledge elements and lack of discrimination and procedural knowledge. It has also been observed that the teachers are no exception to the alternative frameworks and it is possible that there is a vicious circle between the teachers and the students which is being reinforced with time (Saxena 1990). Sometimes teacher's behaviour is not only reinforcing preconceptions, it also challenged those pupil's conceptions who held scientific conception (Hashweh, 1988)

Teachers being a very important factor that influences learning in the classroom, it was decided to study the teacher's understanding of basic concepts of physics. The result of such a study are being reported here.

Plant of Study

A questionnaire consisting of 30 multiple choice type situational questions that tested the understanding of basic concepts of physics are prepared and administered on a group of teachers teaching physics. The responses given by the teachers were analysed and major alternative frameworks were identified

Tool

As mentioned earlier, the tool was in the form of a questionnaire consisting of 30 questions that described a situation and in that context a question was put. The response was sought in terms of four possible responses. (Two questions were exception to this.) Moreover, in order to understand deeper the teacher's idea, teachers were also required to give a brief explanation of the reasoning/logic used by him/her to arrive at the response chosen. The examination of this proved helpful to identify the alternative framework. This technique has been successfully used in many studies earlier (e.g. Saxena 1988, 1990, 1991, 1992). Since it is a long questionnaire,

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few sample questions are being given in Appendix 1. The number of questions in different areas in the questionnaire was as follows :

Area	*No. of questions*
Mechanics	7
Currect Electricity	6
Electrostatics	5
Light	3
Oscillations & Waves	4
Thermodynamics	4
Nuclear decay	1
Total	30*

*Due to some reasons, one question was droped from analysis, leaving total number of questions to 29.

Sample

The sample consisted of 26 teachers teaching physics at senior secondary level in different parts of India. Each teacher had at least masters degree in physics. Out of these 13 teachers had M.Sc, B.Ed degree and six teachers had M.Sc, M.Ed degree. They had teaching experience in the range of one year to 26 years with an average of about 12 years. The sample consisted of both male and female teachers. However, during analysis, the sex of the teachers was ignored.

When questionnaire was administered, no time limit to respond was set. Teachers were given as much time as they required to respond to all the questions. However, it was observed that 90 minutes duration was sufficient to all the teachers.

Analysis of the Responses and Results

Response to each question vas analysed and the reasoning given while choosing the response was examined closely. The following broad conclusions were drawn :

1. All the teachers had responded to almost all the questions. Out of maximum possible 26 × 29 = 754 responses, 698 responses were received. However, in many cases reasoning used to choose the response was not given despite clear instructions to this effect. This made identification of common alternative frameworks difficult. In such a situation only limited conclusion can be drawn.
2. The number of correct responses with correct explanation per teacher out of maximum 29, was 5.96 and correct response irrespective of the explanation being written or not was 12.54. This shows that the less than half the correct responses were supported by correct reasoning. There are 12 questions that were correctly responded by less than 13(50%) teachers. Out of such questions, some questions are given in the Appendix.
3. The analysis of responses to some questions showed clearly the existence of alternative framework or lack of understanding of the basic concept. These are described in brief here :
   (i) The weight of a body inside a satelline is considered zero because (a) 'g' decrease above the surface of the earth (12%) and (b) no gravity exists inside the satalline (8%).

(ii) In a displacement time curve shown (see Fig. 1) velocity at O is:

a. Zero (46%) because S = 0

b. Indeterminate (23%) because V = 0/0 cannot be determined.

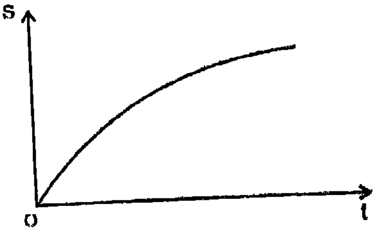

Fig. 1

(iii) Forces acting on a body thrown upward (refer to Q.4 in Appendix) are :

(a) as shown in (b) 42% because body is moving upward and g is downward.

(iv) In Q.6 (see Appendix), the angular momentum is zero (42%) because

- 'Motion is linear'
- 'Angular momentum is in rotational motion'
- 'Only circular motion has angular momentum'.

(v) In Q.9 (see Appendix), the projection of motion is SHM

(a) online AB only (19%)

(b) on line CD only (15%)

(c) on any diameter (62%) because the foot of perpendicular executes SHM.

(vi) In Q.10 (see Appendix), point P' and Q' are in same phase, when the spoke is perpendicular (46%).

(vii) While calculating the electric flux through a hemispherical surface 69% teachers ignored the angle between the surface and the field and arrived at the result $(2\pi R^2)E$.

(viii) 35% teachers thought that the transformer would work with DC source as well and used the usual formula to calculate the DC output.

(ix) To calculate the current in a circuit containing cell and resistors, 39% teachers assumed the cell as constant current source. In response to another question, 19% teachers used similar assumption about the current. In response to another (third) question 45% teachers calculated the heat generated assuming constant current from a battery.

(x) Twelve per cent teachers thought that when half of the lens is covered by an opaque screen, no image would be formed. Equal percentage of teachers opined that half image would be formed in such a situation.

xi) A very large fraction (77%) of teachers opined that in resonance column sound travelled along the curved lines shown (Fig. 2).

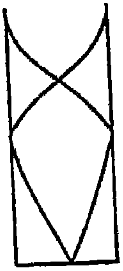

Fig. 2

(xii) About one fourth (23%) teachers were of the opinion that as air pressure decreases with altitude (Q.28) the barometer reading would be less than 76 cm.

(xiii) In response to Q.30 (Appendix) 46% teachers gave the response: (a) i.e. the intensity would be Io with one slit open and another 23% gave the response (c) i.e. the intensity would reduce to half with one slit. In the former case the logic given was that 'no more interference took place'. In the later case, 'the intensity is proportional to the slit width' is the argument.

Discussion and Implications

The examination of the teachers response gives the clear impression that the large number of teachers carried many misconceptions. This is despite the fact that all the teachers are well qualified with teaching experience of many years to their credit. Therefore, it could be safely concluded that similar conditions would prevail elsewhere also.

Secondly, the alternative frameworks are also not confined to a particular area but are spread over all the areas. The misconceptions are related to physics as a whole and not a specific concept or topic.

The existence of large number of misconceptions among the teachers has a serious implication that it is very likely that some of these misconceptions would be passed on or reinforced among the pupils in the classroom as opined by Hashweh (1988) and speculated earlier (Saxena 1990).

This calls for in-service teacher education programme and focus its attention to teachers alternative frameworks and uses active strategies to eliminate them. As experience tells and is supported by the research evidences, merely telling of scientific conception is not sufficient enough to bring about the change in the learner (Bet Sheva and Linn 1988, Moreira and Dominguez 1987, Saxena 1994). It has been argued (Posner *et al.* 1982) that to make the conceptual change, it is necessary to meet the following conditions :

1. There must be dissatisfaction with the existing conception. People are not likely to make major conceptual change until they believe that less redical changes will work.
2. The new conception must be minimally understood. The individual must be able to grasp how experience can be structured by a new conception sufficiently to explore the possibilities inherent in it.
3. A new conception must appear initially plausible. Any new conception adopted must atleast appear to have capacity to solve the problems generated and to fit with other knowledge, experience and help to understand the new experiences.
4. The new conception should have potential to be extended to new areas of inquiry and to have technological and/or explanatory power.

The teacher education programmes are required to keep these points in view and behavioural change in teachers should be motivated and reinforced.

There are many limitations of the study. The sample of teachers is small, therefore, the percentages shown could only be indicator of the trend and the results cannot be generalised. Secondly, though attempt was made to make the questions as unambiguous as possible, if the language might have played an important role and some confusion in the mind of teachers could be due to vagueness or faulty construction of the question (Clerk and Rutherford 2000). Moreover no interview was conducted to verify the interpretation of the responses given leaving some room for misinterpretation of the responses.

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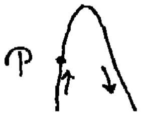
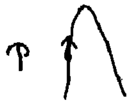
APPENDIX 1

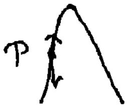
Some of the questions from the questions that were responded to correctly by less than 50% teachers.

Q.4 Projectile of a body is shown. Which of the following diagrams shows the correct direction of force acting on the body, when at point P ?

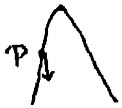




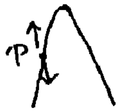
(a)



(b)



(c)



(d)

Reason ______________________

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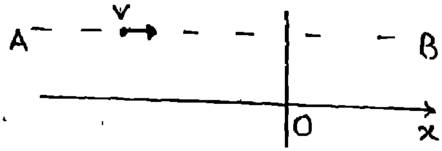
Q.6 A point particle is moving along a straight line AB with constant velocity. The angular momentum of the particle about the origin O

(a) is zero all the time

(b) is constant and non zero

(c) increases with time continuously

(d) increases and then decreases.



Reason ______________________

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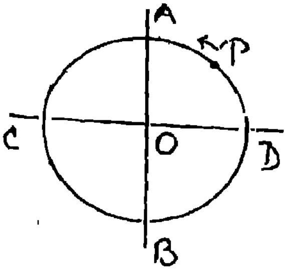
Q.9 A particle P moves with uniform speed on a circle as shown. The projection of its motion is SHM on

(a) line B only

(b) line CD only

(c) any line not necessarily passing through O

(d) only along any diameter.



Reason ______________________

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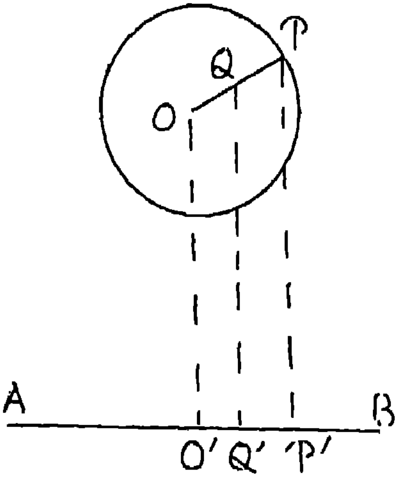
Q.10 A wheel with spokes rotates with constant speed in a vertical plane. P and Q are projections (On a horizontal line AB) of two points P and Q respectively, situated on one spoke. As the wheel rotates, point P' and Q' perform SHM about point O such that they

(a) are always in the same phase
(b) are never in the same phase
(c) are in the same phase when spoke is vertical
(d) will have variable phase difference.



Reason ____________________

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Q.13 The electric flux through a hemishperical surface of radius R placed in a uniform field E parallel to the axis of the circular plate is

(a) $(2\pi R^2)E$
(b) $(\pi R^2)E$
(c) $(4/3)\pi R^3 E$
(d) $(2/3)\pi R^3 E$

Reason ____________________

____

Q.28 A barometer kept in an elevator reads 76 cm when it is at rest. If the elevator goes up with constant speed, the reading will be

(a) zero
(b) 76 cm
(c) > 76 cm
(d) < 76 cm

Reason ____________________

____

Q.30 The slit in a young's double slit experiment have equal width and the source is placed symmetrically with respect to the slits. The intensity of the central fringe is Io. If one of the slits is closed, the intensity at this point will be

(a) Io
(b) Io/4
(c) Io/2
(d) 4 Io

Reason ____________________

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Learning of Organic Chemistry Through Interconversions

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AFTER learning the fundamentals like tetravalency of carbon, nomenclature, isomerism, geometry and shapes of molecules and also the basics of reaction mechanism, different chapters on Chemistry of carbon compounds (organic Chemistry) like hydrocarbons (alkanes, alkenes, alkynes, benzene) in Class XI and halogen derivatives, alcohols, ethers, aldehydes, Ketones, carboxylic acids and their derivatives and amines in Class XII, interconversions of compounds should be practised in the class at least for about 5-6 hours before proceeding to the biomolecules. This will help in revising the important reactions. It is the beauty of organic chemistry that properties of one class of compounds are involved in the preparation of another class of compounds. For example, dehydro halogenation of alkyl halides gives alkenes. Similarly dihydro halogenation of alkene dehalides leads to the formation of alkynes. Acidic hydration of alkynes produces aldehydes and ketones. Oxidation of aldehydes leads to the formation of carboxylic acids and decarboxylation of sodium salts of carboxylic acids on heating with soda lime forms alkanes or arenes. Cyclic polymeriation of alkynes on arromatosation of alkanes beyond n-hexane on heating in the presence of Cr_2O_3/V_2O_5 are the popular paths for entering the class of aromatic compounds. Wurtz reaction i.e. treating alkyl halides with sodium metal in the presence of dry ether or treatment of alkyl halides with alcoholic KCN are used for ascent of series i.e. for increasing number of carbon atoms in a molecule. If we want to decrease the number of carbon atoms in a compound, this can be achieved by following Hoffmann's Bromamide reaction i.e. treating amides with Br_2 and KOH or by carrying out decarboxylation of sodium salt of an acid. With this practice the students will be able to find linkages between different class of compounds and appreciate the systematic learning of organic chemistry. An effort has been made in here to understand different routes for conversion of one class of compounds into another class. Students and teachers are free to follow/suggest their own routes provided chemistry of the route is correct. After describing the routes for ascent and descent of series, a few conversions are dealt with for the benefit of readers as given below :

Routes for Ascent of Series

The following two routes are very popular :

i) By using Wurtz Reaction
ii) By converting alkyl halides into cyanides

2.1 Conversion of CH_4 into C_2H_6 (Wurtz Reaction)

$$\underset{\text{Methane}}{CH_4} + Br_2 \longrightarrow CH_3Br \xrightarrow[\text{dry Ether}]{2Na} \underset{\text{Ethane}}{CH_3\text{-}CH_3}$$

Wurtz Reaction

2.2 Conversion of C_2H_6 into C_4H_{10} (Wurtz Reaction)

$$CH_3 - CH_3 + Br_2 \longrightarrow CH_3 - CH_2 - Br \xrightarrow[\text{dry Ether}]{2Na} \underset{\text{n-Butane}}{CH_3CH_2CH_2CH_3}$$

Wurtz Reaction

It may be remembered that Wurtz reaction is used for the preparation of alkanes containing even number of carbon atoms because if a mixture of two different alkyl halides is taken, then we would be getting a mixture of three alkanes due to side reactions as given below :

$CH_3\text{-}Br + 2Na + Br\text{-}C_2H_5 \longrightarrow CH_3\text{-}C_2H_5 + 2NaBr$ ...(i)

$+$

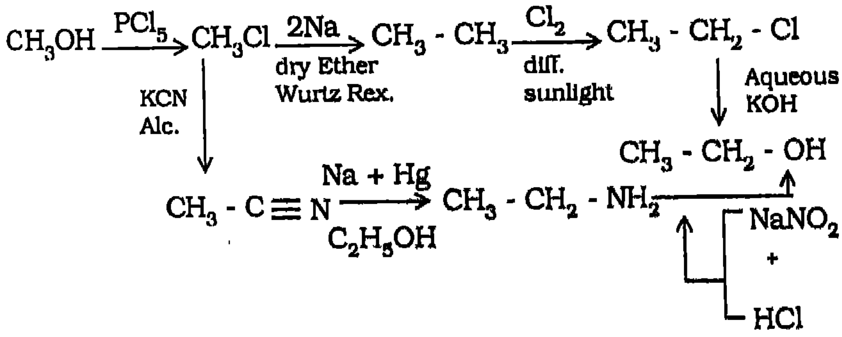
$CH_3\text{-}CH_3$ ...(ii)

$+$

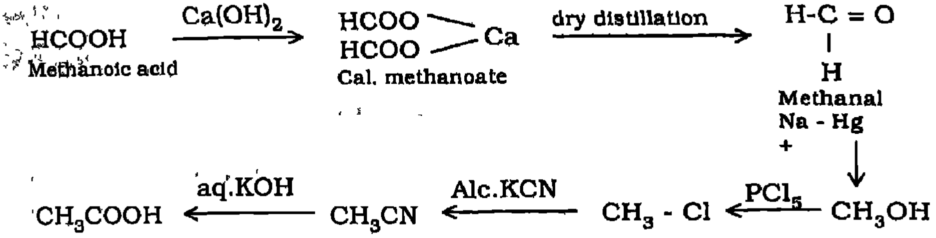
$C_2H_5\text{-}C_2H_5$ ...(iii)

Hence, preparation of an alkane with odd number of carbon atoms should be avoided by Wurtz reaction.

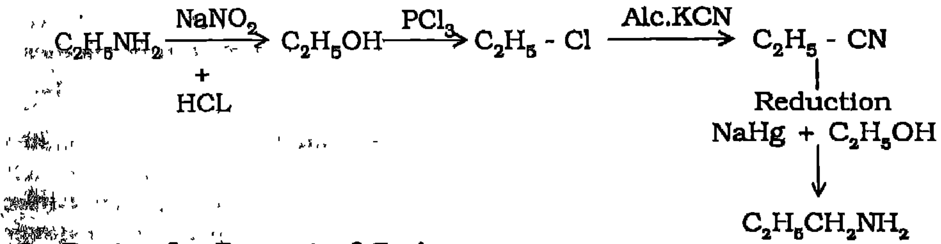
2.3 Conversion of CH_3OH into C_2H_5OH



2.4 Conversion of HCOOH into CH_3COOH



2.5 Conversion of $C_2H_5NH_2$ into $CH_3CH_2CH_2NH_2$



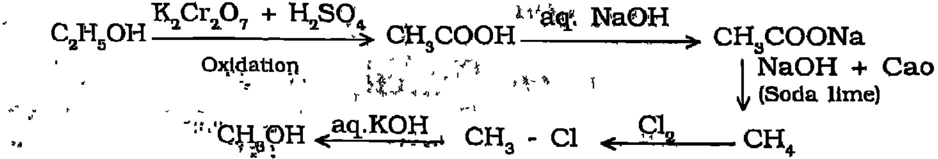
3. *Routes for Descent of Series*

(i) By decarboxylation of sodium salt of fatty acid

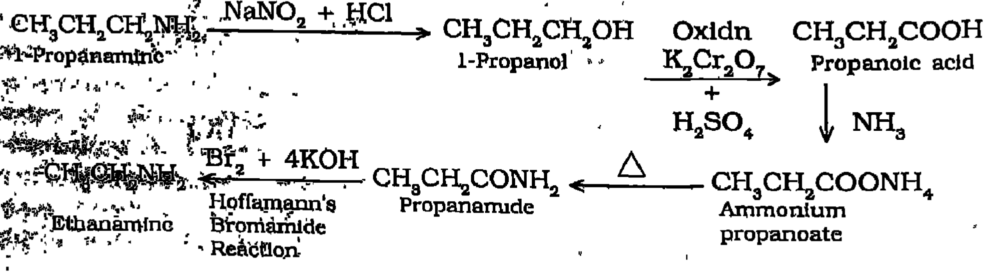
(ii) By using Hoffmann's Bromamide reaction

This is illustrated by taking the following examples:

3.1 Conversion of C_2H_5OH into CH_3OH



3.2 Conversion of $CH_3CH_2CH_2NH_2$ into $CH_3CH_2NH_2$



4. *From Aliphatic to Aromatic Compounds*

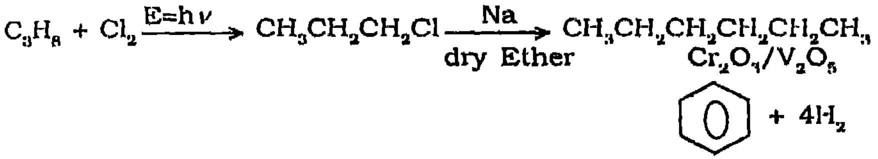
The easiest path for converting aliphatic compounds into aromatic ones is by changing the compound into ethyne which on passing through red hot iron tube at 873K is converted into benzene. Benzene can further be converted into the desired product making use of electrophilic substitution S_E and other reactions of benzene. This point can be clarified by taking the following conversions:

4.1 Conversion of CH4 into C^6H^6

$$CH_4 \xrightarrow[E=h\nu]{Cl_2} CH_3Cl \xrightarrow[\text{dry Ether}]{2Na} CH_3\text{-}CH_3 \xrightarrow{Cl_2} CH_3\text{-}CH_2\text{-}Cl$$

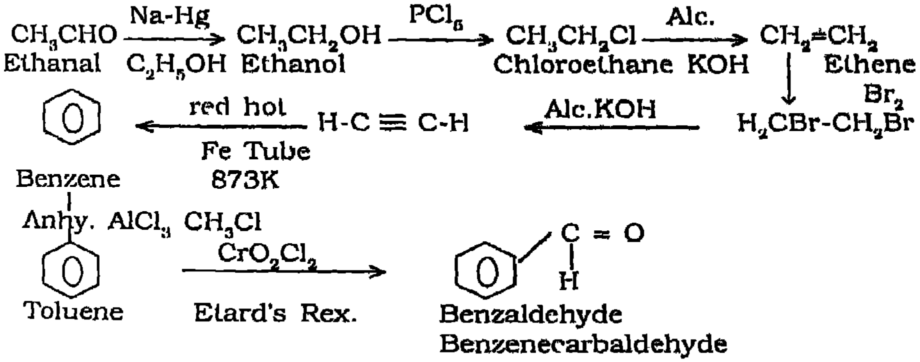
$$\begin{tikzcd} {} \arrow[r, "\text{Alc.KOH}", "-HCl"'] & CH_2{=}CH_2 \arrow[r, "Cl_2"] & CH_2Cl\text{-}CH_2Cl \arrow[r, "\text{Alc.}", "KOH"'] & CH \equiv CH \arrow[d, "873K"', "\text{Red hot Fe Tube}"] \\ & & & \text{Benzene} \end{tikzcd}$$

4.2 Conversion of C_3H_8 into C_6H_6

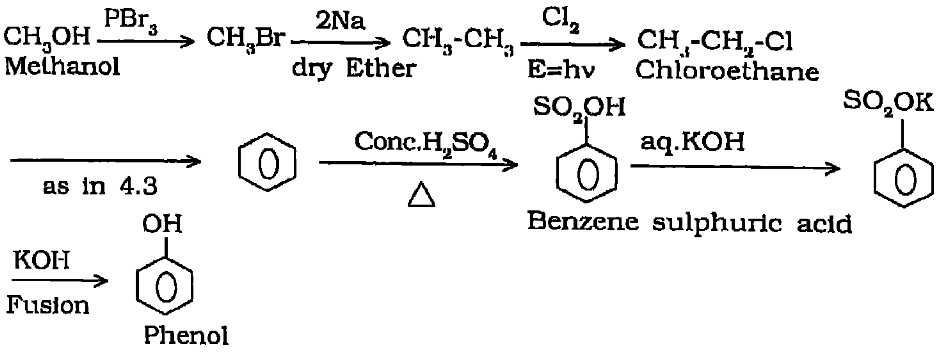

$C_3H_8 + Cl_2 \xrightarrow{E=h\nu} CH_3CH_2CH_2Cl \xrightarrow[\text{dry Ether}]{Na} CH_3CH_2CH_2CH_2CH_2CH_3$
Cr_2O_3/V_2O_5
+ $4H_2$

Making use of the above two reactions, one can very easily enter into the class of aromatic compounds from aliphatic compounds. This point is further elaborated with the help of the following conversions :

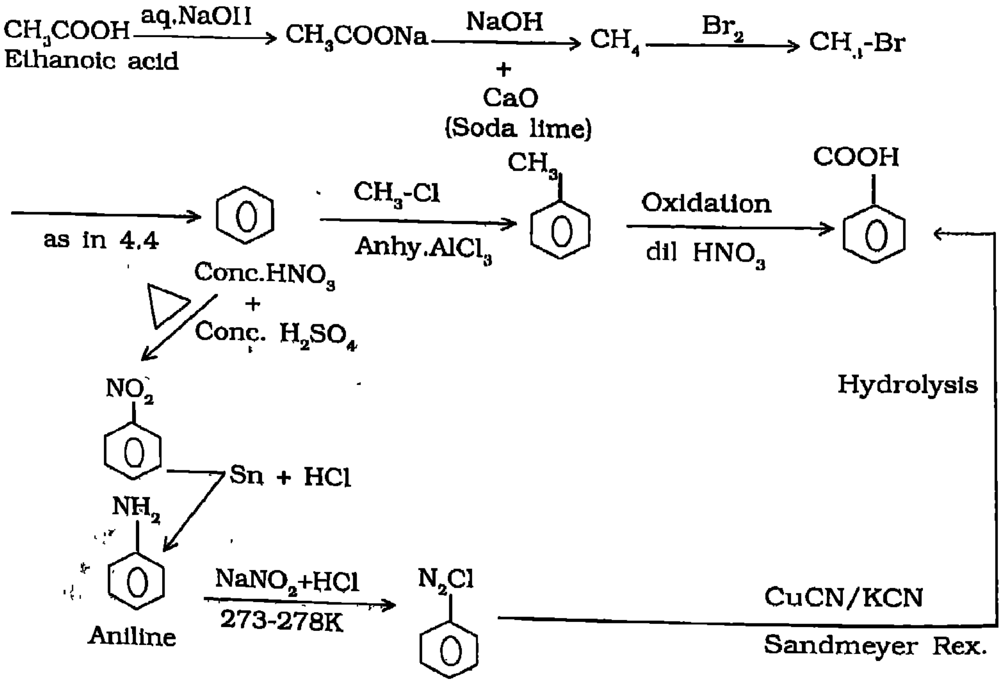
4.3 Conversion of CH_3CHO into C_6H_5CHO



4.4 Conversion of CH_3OH into C_6H_5OH



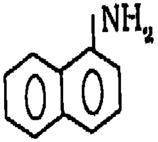
4.5 Conversion of CH_3COOH into C_6H_5COOH



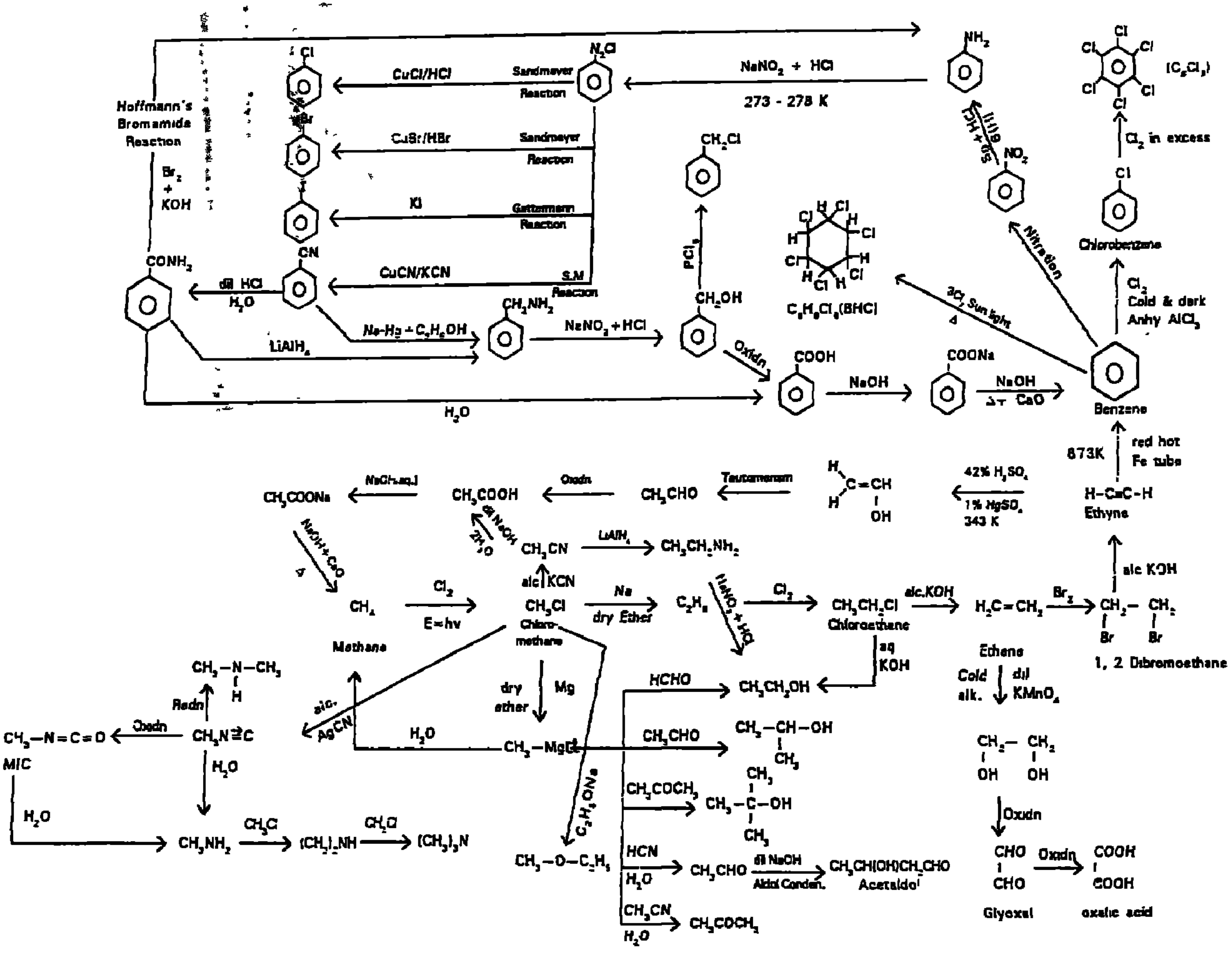
Similarly many other conversions can be tried. Interconversions can be attempted only by those students who have studied organic chemistry very thoroughly and have understood the linkages between different homologous series. Conversion of one compound into the other actually needs brainstorming and leads to creativity. For nurturing of creativity, it is suggested that teachers ask students to practise for a large number of such conversions. This activity throws a challenge especially for the creative students. Slow and middle level learners may develop efficiency by practise. During conversions, it is suggested that names of compounds and reaction conditions must be mentioned to bring more clarity into the subject matter. It is well known that alkyl halides on treatment with aqueous KOH form alcohols whereas alkenes are the major products with alcoholic KOH. The chart given on the next page shows the conversion of one compound into the other. This chart may be useful in going from one class to the other class of organic compounds. The following exercise may be tried.

EXERCISE

How will you affect the following conversions ?

1. CH_3-CH=CH_2 into HCOOH via glycerol
2. CH_3COOH into $(CH_3)_3COH$
3. CH_3COCH_3 into $C_6H_5COCH_3$
4. CH_3OH into 
5. $HC \equiv CH$ into CH_2=CH-CHO

CONVERSIONS IN ORGANIC CHEMISTRY



Impact of Biology on Educational Philosophy

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EIGHTEENTH and Nineteenth Centuries were the centuries of technological developments. These developments were based on the discoveries and inventions made in the field of physical sciences.[1] Considering the philosophy of life and education after the renaissance period, education remained only religion and philosophy. It was only after eighteenth century it became a tool for social change. This was due to some fundamental change in the concept of human behaviour. Earlier to this Aristotle defined man as a rational animal.[2] This gave an impetus for metaphysical thought. Human being became rather a true rational animal, and as a result left all the biological species on earth far behind. As imagination does not have any limit man thought to become the master of this planet. But to become master or ruler one requires physical power also. Here enters another great philosopher of the ages – Karl Marx. He said that "man is an appendage of machine"[3]. This again changed the total concept of human existence. Man started making machines, more perfect and powerful machines and he became the ruler of the earth. These two philosophers changed the nature and scope of educational philosophy. The process of learning did not remain only a metaphysical discussion, or only the pursuit for abstract knowledge. Education now acquired a more dynamic place in the social set up. It became a tool for transferring human behaviour according to the demand and dictum of the society. Man through education had to understand the technological world in which he was to fit in. The educational philosophy was changed for technological based society.

In the meantime what was the position of Biological science ? How was it influencing education with its developments ? The *"Origin of Species"* by Charles Darwin was published in 1855. Perhaps this has given maximum acceleration to biological researches, philosophy and education. The origin of living things in this world was no more traced in scriptures but in the nature.[4] Education was to cope up with it. If one thinks it seriously it will not be difficulty to trace the exponent of natural process of learning, who started their work towards the end of nineteenth century. Ultimately a group of naturalist school of educational philosophers like Nunn, Spencer and Dewey came up. There might have been some disagreement among the naturalists like Spencer, Huxley and others, but the final result was the new slogans like a "return to nature" and "follow nature". Naturalism entered the curriculum.[5] Now consider the discovery of Rober Koch, Louis Pasteur and Alexandar Flehming. These are too well known names to be told to anybody who has got education upto secondary standard. They were all scientists. They were all biologists. They have shaken the world of biological sciences and have made the educational thinkers and planners to change their strategies. If education is to cater to the needs and aspiration of the society and of the individuals then it has to think about the microbiology. Microbiology deals with microorganisms and how the food is spoiled or preserved, or what are the disease-causing agents, at the same time how to get rid of diseases and what are antibiotics. The educationists accepted the change. Physiology and hygiene were included in the school curriculum.

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[1] Russell, B. The Impact of Science on Society, p. 32, 1962.

[2] Taneja, V.R. Educational Thought and Practice, p. 96, 1960.

[3] Marx, K. and Engels, F. Manifesto of the Communist Party p. 51, 1848.

[4] Harper and Row. Topics in the Study of Life, p. 471, 1971.

Another biologist, better known as a psychologist is Freud. Sigmund Freud developed the science of psycho-analysis. This changed the teaching learning process of individual and the masses. The teaching was now related with the totality of individual and later workers (Piaget *et al.*) added stages of growth. Above mentioned are some of the more important discoveries which took place say in last one hundred years. What is happening today ?

There is a branch of Biology known as genetics. This deals with the process of heredity. Again the basic work was done in 1867, by George Mendel, but as the biological scientists were busy at the time arguing Darwinism, this could come to light only at the beginning of the present century. Earlier, the heredity was studied taking whole of an individual organism; their external characters were considered. By the middle of this century more extensive and sophisticated experiments started, which brought to light two important informations. One, the exact process of transfer of characters and the site of characters that is chromosomes, two, their movement during the process of reproduction. In another about thirty years further investigations pushed the study of heredity to molecular level, and it was known as molecular biology. This again brought two things with it. Number one, the character of character-making compounds that is deoxy ribose nucleic acid and Ribose nucleic acid (DNA and RNA) was known. Number two, the behaviour of these compounds during the process of reproduction was visualised. In the process of the study of these compounds, a detailed study on human reproduction was also made. Later on, it was found that DNA and RNA may be manipulated.[6] These manipulated compounds are known as recombinants DNA. Apart from various types of organ transplantation, embryo culture, neurobiology and the space biology, the recombinant DNA is the latest arrival in the field of biology. How are then these researches, their successes and failures influencing the philosophy of education ?

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[5] Nunn, P. Education its data and First Principles.

[6] Woodward, D. and Woodward, W.V. Concept of molecular genetics, T.M.H. 1978

The products of some of the above cited biological researches have already found inroads in educational arena. For example the knowledge of reproduction gave the idea of birth control. If the future generation is to survive happily, they are to know the limit of population which the earth can tolerate. This cannot be done in isolation. The nuclear family is the answer. Education is the means, and therefore the mass education, population education and the adult education programmes have been developed. Here the knowledge of ecology in biology has also influenced the thinking of educationist. Environmental Education became an integral part of education

The transplantation of organs and embryo has become very popular. Let us think of a child conceived by his original mother and nourished in the womb of a foster mother and delivered also through the foster mother.[7]

How will the child react with the society ? Naturally the society will have two categories of children, one from original mother and other from the foster mother. What will be their reaction towards each other ? There will be certainly change in behaviour, may be behaviour of a group, but at this juncture it is difficult to visualise any such things. This is going to happen within coming ten years. We know that education prepares the child for the future. Here again the education has to prepare the child for the coming scenario.[8]

The above example is already in the process with the birth of the test tube (petri-dish) baby. Let us probe little deeper in the coming future. What will happen with the recombinant DNA ? The latest report from the City of Hope Medical Centre, Los Angeles says that a new bacteria has been bred, cultured, made or hybridised.[9] You can use any term you prefer. This new bacteria can synthesise insulin, which was so far not synthesised outside human body. And in the absence of insulin one becomes diabetic. This achievement of biologists is good and helpful. But think of the other side. Can they not breed a harmful bacteria or virus ? Another angle of thinking will be, the effect of insulin producing bacteria inside the human body. Summarizing the recombinant DNA story we can say that it is a Pandora's box, with pleasant and painful gifts. How the future generation is going to open it ? It cannot be kept closed forever. The USA and U.K. have already taken steps for safety measures.

In America the National Institute of Health (NIH) gives certificate to continue with the recombinant DNA research. In U.K. the Gene Manipulation Advisory Group (GMAG) verifies the nature of research work going on.

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[7] Sinha, M.P. Ovulation and Supper Ovulation. *Science Reporter*, New Delhi. May, 1974.

[8] S. Taylor, G.R. The Biological Time Bomb, p. 39, 1969.

[9] A. Riggs *et al.* City of Hope Medical Centre Report. Los Angeles, 1979.

Whatever may be the mode of check unless the people are educated for the future shock the danger for survival will be there. Think of a little remote future. Think of a little higher whim of biologist. Think of intelligence tablet in the market. A kind of baby of the choice of the parents and cast genetically by the geneticist or the indefinite increase of the span of life ? These are possibilities and no more fictions. Then what ? Will there by any romance of life on this plane ? Will not every thing become dull? The concept of biology is to be redefined. Perhaps the difference between living and non-living is that of organisation only. Biology does not deal with only the maintenance of plants and animals but their manipulations also. The changes in the form and behaviour is inevitable. They are natural. Nothing is permanent. If this thought is injected in the mind of the present generation perhaps it will not have mental shock or bewilderment in the future. Education prepares mind to adjust, adapt and manipulate in response to the environment.[10]

This is all easy to say but difficult to do. The educational philosophy has passed through two important phases: 'idealism' and 'naturalism'. Are we going to enter a third phase ? Can we say in the term of Huxley that the coming phase will be known as 'laboratorism'[11] or 'experimentalism' ? Can we educate the child as we like; that will be 'laboratorism or experimentalism'. If we educate the child as the society needs then it will be realism. Whatever may be the means the end is future of biology and biology based educational philosophy. This was visualised by Jawaharlal Nehru when he wrote to Priyadarshini Indira in 1933, "Such is today. The making of tomorrow lies with you and your generation, the millions of girls and boys all over the world who are growing up and training themselves to take part in this tomorrow."[12] When Nehru talked about training, education certainly was in his mind. Nehru is better known as a statesman and a man of literature, but he was a biologist too.

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[10] Toffler, A Future Shock, p. 5A-7A, 1973.

[11] Huxley, A Brave New World, 1958.

[12] Nehru, J. Glimpses of World History, p. 983, 1934, Reprinted 1965.

Research Related to Minimum Competency in Mathematics —

A Review Study

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THE achievement test of high school students in the United States of America in early seventies revealed a decline in fundamental arithmetic competence to perform four basic arithmetic operations of addition, subtraction, multiplication and division for whole numbers, decimal numbers and fractions. The debate which followed attributed this to various factors such as new mathematics, availability of handhold calculators and a shift in the concerns and direction of society as a whole. The public outcry led to enactment of law for the institution of state level assessment to ensure all high school students acquire minimum competency in mathematics before graduation. The February '78 issue of *Mathematics Teacher* covered the issues involved from several perspectives. Back references can be obtained from these papers. The issues regarding minimum competency are :

(i) What combination of teachers, administrators, district or state development personnel and students should be involved in identifying minimum levels of learning (MLLs) and constructing items ?

(ii) When should basic skills tests be administered ?

(iii) How many items should a student answer correctly to ensure competency?

(iv) How should the results of minimal competence testing be related to graduation requirements ?

(v) How should these be related to evaluation of teachers and of teaching-learning process ?

(vi) Instructional material and parental involvement for remedial courses.

The minimum competency was defined as an attainment of those basic skills in mathematics which were needed by a student to function effectively in adult society. However, it was considered a relative term to be used in a specific situation because of changing need of the society and technology. The basic mathematical skills were identified by the National Council of Supervisors of Mathematics (NCSM) as given below :

1. Problem solving
2. Applying mathematics to everyday situations
3. Alertness to the reasonableness of results
4. Estimation and approximation
5. Appropriate computational skills
6. Geometry
7. Measurement
8. Reading, interpreting and constructing table, charts and graphs
9. Using mathematics to predict

10. Computer literacy.

A survey study was conducted to identify and validate important basic skills that pupils need to function effectively in everyday life, including vocational pursuits. The response sheets from individuals and mathematics educators revealed 88 per cent agreement on twenty-five most important skills. The order of skills determined from those responses is as follows :

Order of Skills as Determined from the National Mathematics Educators' Responses :

1. make change
2. add and subtract whole numbers
3. add and subtract decimals
4. use a ruler in the metric and customary systems
5. multiply and divide whole numbers
6. use scales in the metric and customary systems
7. use a thermometer in the metric and customary systems
8. Read a map
9. determine liquid measure in the metric and customary systems
10. estimate length and distance
11. recognize and complete consumer-related number problems
12. estimate the passing of time
13. multiply and divide decimals
14. estimate money totals
15. recognize shapes
16. estimate size and weight
17. read tables, graphs, and charts
18. prepare budgets
19. compute taxes and interest
20. add and subtract common fractions
21. estimate area and volume
22. express a common fraction as a decimal and vice versa
23. read gauges and meters
24. estimate markup and discounts
25. express a common fraction as a per cent
26. recognize positions
27. estimate per cents
28. estimate commissions
29. compute markups and discounts
30. apply the properties of squares and rectangles
31. set up and solve simple equations
32. compute area and volume
33. interpret quantitative data
34. recognize geometric patterns
35. multiply and divide common fractions
36. compute the perimeter and circumference
37. calculate ratio and proportion
38. read scale drawings
39. estimate ratio and proportion
40. know the properties of squares, rectangles, and parallel and perpendicular lines
41. collect quantitative data
42. use a protractor
43. apply the properties of circles and triangles
44. solve simple probability problems
45. apply the properties of parallel and perpendicular lines
46. know the properties of circles, triangles, and right triangles
47. know the properties of similar and congruent figures
48. construct tables, graphs and charts
49. apply the properties of similar and congruent figures
50. create geometric patterns
51. use a caliper in the metric and

customary systems

52. use a micrometer in the metric and customary systems
53. construct scale drawings
54. apply the properties of right triangles (trigonometry).

But it was emphasised that the list should not lead the minimum becoming maximum. The studies related to assessment instruments pointed that standardised norm-referenced tests are inappropriate for minimal competency programme as these tests do not generally yield diagnostic information necessary for remedial. Content referenced achievement test should be designed that measures students progress towards the mastery of specific objectives. Either a pool of test items or computer generated test items that test the objective can be used. The teachers can randomly select the test items from sets of items stored in the computer or can be randomly generated according to specific parameters. Emphasis was given to generate survey tests in order to have an idea of students achievement using two free-response items or three multiple-choice items to establish exactly which specific objective have been mastered. It was further suggested that survival skills test should be administered to students to determine and maintain their level of competence in arithmetic skills and those students who fail to clear the test appropriate improvement programme could be designed. The minimal level of competence was fixed for at least 75 per cent proficiency (three out of four questions) or 80 per cent proficiency for all. At the same time it was apprehended that the minimal competency testing will degenerate the whole mathematics curriculum to identify basic skills areas only and whole testing movement was shown based on the following false premises :

a. A list of the basic skills in mathematics exists or can be created.
b. Minimal competency tests provide invalid measures of performance.
c. Measures for deciding minimal competency levels should be determined after the data are collected.
d. The skills needed to produce a score above the acceptable minimum competence level will be retained in adult life.

It was argued that basic skills in mathematics cannot be created permanently because of changing needs of society and is therefore subject to change. The scores on minimal competency test are only indicators of performance but not direct measures of performance in real life situation or predictors of job performance. So competency test cannot be taken as reliable scale/tool to ensure that student is competent to function mathematically in the society. Minimal competency being relative term its level cannot be decided using normative approach. The experience has also revealed that facts learnt mechanically cannot be retained for a longer time. Thus minimal competency testing programme based on such questionable premises will have far-reaching consequences. It will directly influence the mathematics curriculum and classroom teaching/learning process in different ways viz. (i) mathematics curriculum will be narrowed to basic skill areas only; (ii) arithmetic computation will be given greater emphasis in the class; (iii) teaching will be test oriented and; (iv) minimum competency levels will serve as maximum performance goals.

To state minimal objectives and testing 'Michigan Accountability Model' was developed which consisted of the following six-step process :

(i) defining goals
(ii) translating these goals into measurable student performance objectives
(iii) conducting needs assessment on the basis of the objectives
(vi) analyzing and developing delivery systems and instructional programmes that will help students teach the objectives
(v) evaluating the programme to determine the extent to which they have helped students attain the objectives
(vi) reviewing all the steps above and making recommendations for improvement.

The review can provide a better basis to judge the desirability of the minimum competency programme in our country. However, the United States of America has discontinued the minimum level of competency programme and now they have launched a mathematics programme that should lead to achieve professional standards. In other words, the present curriculum reform movement is visualized as a movement that will ensure that all students have the opportunity to acquire a 'dynamic form of mathematical literacing' which enable them to participate as informed citizens and skilled workers in a rapidly changing technological society.

Assessing Student Progress in Science

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The debate continues on how to assess learner achievement in the public schools. One school of thought stresses high state mandated standards using multiple choice test items. Either standardized tests or criterion referenced tests (CRTs) are then used to determine student progress. Toward the other end of the continuum, there are advocates of constructivism as a philosophy of education whereby student achievement is ascertained in the local classroom. Both procedures will be analyzed by looking at perceived strengths and weaknesses.

State Mandated Testing in Science

Forty-nine states out of fifty have some form of state mandated tests for all students to take within their respective borders. These tests may be given once a year in grades two, four, eight and twelve. Or, they may be given more frequently such as each school year. A few states have high stakes testing whereby a student may not receive a high school diploma if he/she fails to pass the exit exam. These states may also have a requirement for students to pass a test to be promoted to a higher grade level at the end of the school year, even on the kindergarten to grade one level. Generally, standardized tests have a better reputation for being pilot tested as compared to CRTs. The former is published by a leading publishing company whereby CRTs are written on the state level in which funds tend to be scarce to do pilot testing on their tests. Iowa is the only state which has no mandated testing. Each time a state governor comes in anew into office, a new mandated test comes into being. Missouri, for example, during the last twelve years has had the following state mandated tests :

1. Basic Essential Skills Test (BEST).
2. Missouri Mastery and Achievement Tests (MMAT).
3. Missouri Assessment Program (MAP).

An advantage of CRTs is that objectives for teacher use are available which align with the state mandated test items. The levels for achievement on state mandated tests such as basic, proficient, and excellent, may be quite arbitrary. Regardless of using standardized or CRTs, it is quite difficult to develop test items valid for that which has been taught in a specific classroom. This is more true for standardized as compared to CRTs (See Ediger, 2000, 244-249).

Advantages given for state mandated tests are the following :

1. student achievement is to be raised with results revealed from testing.
2. an issued report card can make competitive comparisons among

school districts as to how well students are achieving within a state.

3. high expectations of students are to be expected in order that test results are higher than for previously administered tests.
4. accountability on the teacher's part may well be in the offing.
5. poorly achieving schools may eventually be eliminated or taken over by the state (Ediger, 1996, Chapter Ten).

There are numerous weaknesses in state mandated testing; these include the following :

1. tests tend to be weak on being valid unless there are related objectives for teachers to use in teaching. Teachers may then align their teaching with these objectives. Standardized tests do not have these available objectives.
2. test items are written by those removed from the local classroom setting. This tends to minimize closeness in relationships between the tests, teachers, and their students.
3. tests which omit certain academic disciplines may not be emphasized as being important in the local curriculum. Thus, if science is minimized or even omitted, then it may not receive the attention needed in the curriculum.
4. tests not pilot tested adequately tend to lack reliability, be it test/retest, alternative forms, or split half.
5. test items may be written even though a lack of money is available by states to work out a quality CRT (Ediger, 1996, 120-126). The above named criticisms form a basis for test modification and improvement. Measurement and test specialists need to continually improve from what is to *what should be.*

Using Standardized Tests

Standardized tests may be used on the state level to measure student achievement. Advantages of quality standardized tests to measure science achievement over that of CRTs are the following:

1. they have been more carefully pilot tested with publishing companies having money available to modify/change what was originally weak on the proposed standardized test.
2. they list in their manuals and in the last edition of *The Mental Measurements Yearbook* data on validity and reliability, as well on whom the test was standardized on.
3. they have more carefully edited test items than do CRTs.
4. they are written by specialists in the measurement movement.
5. they tend to base the standardization group on students who are representative of different socio-economic levels in society, such as the per cent of rural students taking the test in the pilot study are equivalent in number to the per cent of people living in rural areas in the nation.

Disadvantages or using standardized tests to appraise learner progress are the following:

1. they lack validity in terms of testing what is taught in a local classroom.

2. they are written by testing and measurement specialists who have no connection or knowledge of those being tested.
3. no provision is made for individual differences in that every student receives the same directions, the same time limits, and the same consideration for taking the test. The "one size fits all" is certainly in evidence.
4. they may minimize certain academic disciplines such as science and thus hinder teachers from teaching an adequate number of science units in the classroom with the same/similar attention given to the 3Rs of reading, writing, and arithmetic. What is not tested is then not taught.
5. they provide little information in terms of feedback from student test results on how to improve the local curriculum. A single numerical result such as a percentile does not tell much about a learner's progress. Standardized tests are machine scored and multiple choice test items are used. Business and friendly letters written by students, as well as oral communication skills, cannot be machine scored (Ediger, 1999, 233-240).

Portfolio Use in Science and the Student

Portfolios are discussed frequently in the educational literature as a means to ascertain student achievement. Here the classroom teacher with the involved student may develop a portfolio to reveal the latter's achievement in science. Portfolio contents may and should harmonize with the stated objectives of instruction. The following are examples of products and processes from students in ongoing science units of study:

1. written work including summaries, outlines, conclusions, and reports.
2. cassette recordings of oral work such as book reports, discussions participated in, committee engagements, oral reading from the basal, and peer group work in science units of study.
3. video tapes of cooperative work to notice the quality of interactions among members.
4. art products to show what has been learned in science.
5. drawings and diagrams related directly to emphasizing selected concepts and generalizations in science.
6. dramatizations in studying biographies of famous scientists.
7. snapshots of construction activities such as a solar unit.
8. charts made to indicate what has been learned such as developing a flow or narrative chart.
9. graphs developed to indicate items such as showing temperature readings over a period of time.
10. collections made such as igneous, sedimentary and metamorphic rocks.

Entries made may be deleted and added in time. Portfolio results are useful

1. for parent/teacher conferences to show student progress.
2. for teachers to notice sequential progress of learners and to diagnose

what additional needs a leaner may have.

3. for responsible lay people to assess student achievement.
4. for students to reflect upon their very own achievement.
5. for school administrators to use in appraising teaching quality.

Rubrics may be used to assess each portfolio. Raters of portfolios should have prior knowledge of criteria to be used in evaluating the quality of each. Thus, criteria to be used in assessment should have clearly stated standards for each of the Likert Scale levels in order to differentiate quality of the portfolio for different levels of accomplishment.

Disadvantages for using rubrics to assess learner achievement in science for public scrutiny are the following :

1. they are complex and time consuming to interpret. There are no single machine scored numerical results such as percentiles to inform the lay public as to student achievement.
2. they may lack validity in evaluation such as when two or more rate each portfolio. Interscorer reliability might then be weak since the raters look at different things in the portfolio. This can be true, even with well designed rubrics used in the assessment process.
3. they can be too voluminous to look at by parents in conferences with the teacher or learner progress in science. Contents in a portfolio need to be adequately delimited to show student achievement, but not become cumbersome to evaluate.
4. they can be highly subjective in the selection of science entries when the student chooses only the best for the portfolio, rather than a representative sampling.
5. they may become too complicated for teacher use to diagnose and remediate student learnings in science (Ediger, 2000, Chapter Six).

Journal Writing in Science

Journal writings of science learnings by students may be used in the assessment process. The lay public may not be able to interpret needed information on journal writings of student achievement in science, but they are valuable for teachers and parents to use in assessing achievement. What might a student write in a Journal ?

1. what was achieved in a daily lesson in science.
2. questions the learner has which need answering.
3. problems identified in science which take deliberation and time in solving.
4. projects to be made to clarify selected concepts and generalization in science.
5. suggested plans for cooperative learning in making a model in science (Ediger, 1997-1998, 56-60).

Teacher Written Test Items in Science

Too frequently, the results from students of teacher written tests are almost completely eliminated from consideration when looking at educational periodicals, and yet the science teacher knows which subject matter and skills have been taught in science. The teacher may then write a highly valid test covering what has been taught. In addition to multiple choice test items which very frequently appear on standardized and CRTs, the science teacher may also write essay test items for students to respond to. These relevant test items can make for higher levels of thinking such as critical and creative thinking as well as problem solving. The chances are that a well written teacher developed test will also assist students to apply what has been learned in science. It is important to stress students achievement on different levels of complexity in the cognitive domain, such as recall, comprehension, application, analysis, synthesis, and evaluation (See Bloom, 1956). Essay test items need to be those which help students to think about learnings obtained in science, not merely factual content. The following criteria for writing essay test items in science are vital:

1. they emphasize the higher levels of cognition.
2. they are clearly written so that students know what is wanted. Hazy, vague items need to be omitted.
3. they are valid in terms of covering that which has been taught.
4. they stress the importance of reliability be it test/retest, split-half, or alternative forms.
5. the results are used to diagnose and remediate what students did not know.

In addition to multiple choice and essay, the teacher may also write true/false test items. It is true that students may know nothing about the subject matter in true/false test items and still get 50% correct through guessing. However, the guessing factor may best be minimized by having a learner correct the part which was false such as in the following : Dinosaurs lived in the Cenozoic era. The student may then cross out that which was incorrect — Cenozoic — and write *Mesozoic* in its place. True/false items do tend to measure recall of information or factual content; however, it is also true that there are vital bits of information which students should know in science. True/false test items should then be

1. valid in terms of covering what has been taught.
2. reliable when measuring student achievement.
3. clearly written so that an answer given by students is either true or false.
4. written so there is room for the correct response above the erroneous part of the test item.
5. written in terms of stressing higher cognitive domains, if possible.

A quality programme of assessment should be in evidence for students. Too much testing robs learners of instructional time. There is so much students need to learn. Expectancies from the business world in terms of student achievement need to be reasonable and not overwhelming. High stakes testing is quite questionable in value. The author wants the best for students in education and life in general. High states testing, if the subject matter therein is too complex, benefits no one. Learners need to feel challenge and yet achieve as much as reasonably possible (Ediger, 1999, Chapter Seven).

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Students' Achievement and Cooperative Learning Method in Mathematics at Upper Primary Level

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EDUCATION is to be shaped in such a way that the unwanted and traditional methods, which do not help to improve the performance in line with the present needs should be pushed backward and new innovated methods should be tried now and then. Keeping this idea as the base of present education, many changes have occurred in terms of methods, materials, learning styles, evaluation etc. While addressing "education for all" as the main objective of the elementary education, it is also important to see that the quality of teaching and learning gets upgraded. Group learning is the best device for various reasons. In the development of group learning various methods are being tried and evolving. Of the various methods of group learning, cooperative learning is the talk in the present educational scenario. Motivated by this, the investigators have attempted to study the effectiveness of cooperative learning method in enhancing the achievement of the students in Mathematics at upper primary level.

Objectives of the Study

The following are the objectives of the present study.

1. To study the effectiveness of cooperative learning method in enhancing the Mathematics achievement of the students at upper primary level.
2. To study the effect of variables such as sex, and standard on the achievement of the students under cooperative learning method.

Methodology Used in the Study

Sample of the Study

A total of 120 students constituted the sample chosen from three schools in Coimbatore district of Tamil Nadu State. These students belonged to VII and VIII standards. Among these, 60 students were treated as control group and the remaining 60 were the experimental group. The experimental group consisted of 30 students of Standard VII and 30 students of Standard VIII. The number of students (sample) for the control group was similar to that of the experimental group.

Tools Used

Achievement tests were conducted in Mathematics to both VII and VIII standards. The content areas were selected from Mathematics textbooks prescribed by the Government of Tamil Nadu.

Data Collection Procedure

The investigators have used the control group post-test design in this study. The experimental group students learnt the content areas under the cooperative learning method, whereas the control group learnt the same topics (subject matters of mathematics) through conventional method of teaching and they were not exposed to cooperative learning. To know the effectiveness of cooperative learning method, the investigators have administered the achievement tests to both control and experimental groups.

Findings of the Study

Data Analysis

Mean, Standard Deviation and 't' test were computed to know the significant of difference between the mean achievement scores of the experimental group and control group and also the analysis of the performance of both experimental and control groups as per the variables such as sex and educational standards of the students.

Table 1 shows that there is significant difference between the mean achievement scores of control and experimental group students belonging to Standard VII at the upper primary level and it is interpretated that the experimental group students were better than the control group students and therefore, cooperative learning contributed to the better performance of experimental group students.

Table 1

General Comparison of achievement mean scores of Control and Experimental groups — VII standard

VII-Std. groups	*No.*	*Mean*	*SD*	*Calculated "t"*	*Result*
Control	60	54.08	11.99	6.156	Significant
Experimental	60	67.23	11.37		

Table 2

Comparison of achievement means scores of VIII — Standard Control and Experimental groups

VIII-Std. groups	*No.*	*Mean*	*SD*	*Calculated "t"*	*Result*
Control	60	53.27	11.39	5.44	Significant
Experimental	60	65.7	13.54		

Table 2 shows that there is significant difference between the mean achievement scores of control and experimental group students belong to Standard VIII at the upper primary level.

Table 3 shows that there is no significant difference between the achievement mean scores of VII Standard and VIII Standard students of experimental group at the upper primary level.

Table 4 shows that there is no significant difference between the achievement mean scores of male and female students of experimental group (under cooperative learning method) at the upper primary level.

Conclusions

1. Cooperative learning contributes a lot to improve the academic performance of the students in VII and VIII Standards in learning Mathematics.
2. The standard has no effect on the performance of experimental group students and so the effectiveness of cooperative learning can be generalised.
3. The gender has no effect on the performance of experimental group students and so the effectiveness of cooperative learning can be generalised.

Scope of the Study

The result of this study will throw light on the effectiveness of cooperative learning method in enhancing the achievement of the students at the middle school level in mathematics. The findings will be helpful for the teachers to practice the cooperative learning method for the better performance of the students in mathematics at the middle school level. This will motivate the future researchers to carry on similar studies on other school subjects for various grades.

Table 3
Standard-wise comparison of achievement mean scores of experimental group students

Standard	*No.*	*Mean*	*SD*	*Calculated "t"*	*Result*
VII Std	60	67.23	13.5	0.672	Significant
VIII Std	60	65.7	11.37		

Table 4
Sex-wise comparison of achievement mean scores of experimental group students

Sex	*No.*	*Mean*	*SD*	*Calculated "t"*	*Result*
Male	60	67.37	13.71	0.789	Not Significant
Female	60	65.57	11.15		

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How to Facilitate Students Learning in Mathematics

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THERE are too many opinions regarding the aspects of learning—how it takes place, what the best means of promoting it are, and many other matters pertaining to it, but it is an accepted fact that learning does take place. Learning occurs in and out of school and is continuous from the birth to the death. Psychologists have come to agree that trial-success learning, conditioning, and insight are valuable as phases of the learning process if and when they are used appropriately. The achievement of worthy outcomes, whether these be the forming of connections or habits, changing behaviour, or the developing of insight or understanding, is not dependent upon the realisation of any one point of view of learning but upon the application of the principles that fit a specific learning situation. No single learning theory accounts for all the problems and facts of learning but the different theories point to one important goal—growth of the child in terms of integrated knowledge or behaviour, understanding, skills and attitudes.

Since learning is an active process on the part of the learner, it is not possible for the teacher to learn for the students. The teacher cannot make the students learn, but the former can have a tremendous influence on learning. The teacher can motivate the learner by bringing the latter to see the connection between the learning problem and some important need or interest of the student. The teacher can help the learner make those reactions which are to be learned. In other cases, the teacher may help the learner acquire the appropriate reaction by guiding his thinking through questions that focus attention in particular aspects of the problem, which might otherwise be overlooked.

As in the case of other teachers, many qualities are expected of the teacher of mathematics. His obligations not only are confined to the classroom but are extended in many other directions also. Kumar (1998) claims — How to teach mathematics is really a difficult task to be performed. Teachers are unable to apply different methods and techniques in their presentation. This is not due to a single factor but many factors are responsible for the same. It is true that no teacher can do a thoroughly good job of teaching mathematics unless he/she is willing to make a careful analysis of his/her job and to be guided by learning principles. Teaching is meaningless if learning does not take place and it is expected on the part of a teacher that he/she will consider conditions of learning—desire to learn.

capacity to learn and deligence to make he teaching meaningful. A mathema-ics teacher has to guide and direct students learning and for this purpose he/she may take cognizance of the points discussed below while planning and transacting mathematics on his/her class.

By Making Student's Attitude Favourable towards Mathematics

An individual can learn only if he or she has favourable attitude towards the subject to be studied. Attitude has greater correlation with achievement. Kumar (1998) has found that attitude towards mathematics is positively and significantly correlated with achievement in mathematics. He further found that a group with a high attitude towards mathematics is significantly superior in its achievement in mathematics in comparison to the group with low attitude towards mathematics. So, we can conclude that attitude has its bearing on learning and achievement.

It is a general notion that mathematics is a dull, boring and difficult subject. Most of the students find it difficult to enjoy and they have greater fear to deal with it. The teacher of mathematics has to convey its importance to motivate the students. Usually the teachers of mathematics become arrogant and convey it as difficult subject. They often announce that only a very few promising can learn it and it is not meant for average students. These negative remarks along with mathematics teacher's autocratic, non-smiling, serious behaviour make the students attitude unfavourable towards the learning of mathematics. It is the first and foremost duty of a mathematics teacher to behave in a manner so as to make the students' attitude favourable towards mathematics because learning cannot take place if the students have unfavourable attitude towards the subject to be studied. In this connection it is desirable from the mathematics teacher to behave politely and convey pleasing, sympathetic and positive remarks like—it is difficult to learn but humans are capable to learn any task; or we are very much here to help you; or say we will solve the problems together and so on.

By Arranging Diagnostic and Remedial Classes

If the students have not learnt something important due to some reason or other they may find it difficult to understand the other concepts of mathematics based on previous unlearned concepts. This is due to very hierarchical, logical and sequential nature of mathematics as a subject that its concepts are very much related with similar mathematical concepts. If one does not understand the concepts like point and line he/she will find it difficult to understand and concepts like angle and triangle. So, for better students learning diagnostic classes and subsequent remedial classes are essential. This will help the teachers to know the weaknesses of the students to apply reformative measures for better solution of the problem. By asking few basic questions in the class the diagnosis can be made even in the general classes. In this regard, the teachers have to keep in mind that teaching has no meaning if learning is not taking place.

By Determining Objectives in Behavioural Terms and Applying Objective based Evaluation

Objective's specification provides the teacher specific direction and if objectives are specified in terms of behavioural changes the task of teacher becomes easy because for him selection of teaching activities become more specific and purposeful. The teacher specify the objectives as — The students will be able to define triangle — The students will be able to differentiate between different types of triangle etc. These specifications certainly help the teacher to decide the techniques to be utilised, the teaching aids to be used, the questions to be asked etc. In this way we see that the teaching is defined in terms of learning, i.e., what the students will learn ? While determining objectives Blomm's taxanomy of educational objectives could be taken into account. Accordingly objectives may be specified as knowledge, understanding, application, skill, interest and attitude. Keeping in view cognitive, affective and psycho-motor domains of educational objectives the teacher can specify teaching activities for better learning outcomes.

Objectives based evaluation helps the teachers to know which particular specified objectives have not been achieved. This provides a feedback to know the weaknesses of the teaching, curriculum, presentation etc. As evaluation has direct impact on learning process, the objectives based evaluation will help to facilitate achievement of the learning outcomes among the students.

By Managing the Amount, Kind and Distribution of Practice

Mathematics is a subject in which practice or drill is of great importance. Practice not only leads to perfection in carrying out calculations, but it also provides confidence and insight to the students to solve difficult and new problems. It is the task of the mathematics teacher to manage amount, kind and distribution of the drill exercises. As an experienced practitioner of the mathematics as a subject the mathematics teacher has to decide the amount of the practice, i.e., how much practice is needed in a particular topic or how much practice is needed for students with varying capabilities and so on. He has to decide the nature and difficulty level of the drill exercises, i.e., to solve, to draw, to name, to calculate within the given period of time. Keeping in view the level of the students and the time available the distribution of the drill exercises in terms of number and variety is a crucial task of the teacher. A teacher who is capable to manage the amount, kind and distribution of practice may provide better learning environment for mastering skills in mathematics because this is a subject which demands more practice for better understanding and learning. The mathematics teacher should also provide the pupils abundant opportunity to use skills, habits and abilities acquired by them.

By Finding the Learner's Difficulty

Kumar (1998) observed that teachers usually engage themselves in solving problems in a mechanical manner. Conceptual framework of mathematics teaching is usually ignored and consequently the students too begin to solve the problems mechanically and often in the course of time a few of them resort to cramming the steps of problems. Really, it is a sad state of mathematics teaching which does not encourage the students in their learning. Teachers know and they should know where the students feel difficulties. If the teachers feel concerned with difficulties faced by the students they can modify their teaching strategies and do justice with the process of learning.

Good teaching and learning of mathematics are possible only if the teacher is friendly and approachable, knows his/her subject and is prepared to solve students difficulties. Modern pedagogy recognises more clearly than ever that in the learning situation the personal influence of the teacher is much more significant than the subject matter achievement alone, so the teachers of mathematics need to be democratic, polite and friendly to know students difficulties and help them to overcome these.

By Increasing the Participation of the Students

Usually teachers solve problems on their own in the class without due help from the students and ask few questions, if at all, only from the brighter students, and in the process participation of average and poor students is often ignored. Teachers behave as if they have little concern for students participation. They themselves ask very few questions and allow still fewer students to raise questions, in the class. If they put questions to develop the concept and distribute the questions keeping in view the level of the students and standard of the questions, they can increase the participation of the students in the process of teaching/learning. Once the participation of the students is increased the students will start learning with due interest and motivation.

By Providing Planned Assignments

Kumar (1998) observed that assignments in mathematics are neither designed properly nor checked or evaluated with care. The teachers have to consider the nature, amount, types, correction and evaluation of assignments for better learning of mathematics. Planned assignments not only provide an opportunity to students to solve mathematical problems but they help in habit formation and tackling the task in a more planned way. If the teachers plan assignments considering educational objectives and requirements for all-round development of students, then will facilitate development of proper understanding of mathematical concepts and skills in learning in mathematics. The assignment may be verbal or non-verbal to develop power and speed of the students. Teachers have to decide and provide different types of assignments to develop students' power of solving difficult problems and power of solving the problems with speed and accuracy.

By Suggesting Few Ways for Self-study

A well known mathematician once suggested — never read mathematics, always adopt paper and a pen to do mathematics. This is one of the guiding principle for self-study in mathematics. How to plan self-study is a difficult task. An experienced teacher, who is well versed with the nature of the subject, can guide the students in planning self study.

By Providing Opportunity for Self-activity

National Curriculum Framework for School Education, 2000 (A Draft for Discussion) prepared by the NCERT suggests that mathematics learning should be imparted through activities from the very beginning of school education, i.e., from the primary stage itself. The framework further suggests that these activities may involve the use of concrete materials, models, patterns, charts, pictures, posters, games, puzzles and experiments. The framework is of the opinion that to help exploration of mathematical facts through experimentation a mathematics corner could be setup in the existing science laboratories. It is a well accepted fact that the enhancement learning takes place through self-activity. A child learns to do by doing that activity or he learns what he experiences. A child cannot learn to solve a problem or handle a trigonometrical or geometrical devise by merely listening or watching others doing so. If an activity is performed by the students, the learning will be more purposeful specially in a subject like mathematics which requires not only proper tackling of the problems to arrive at their solutions but also skills of proper handling of geometrical tools and devices as well.

The teacher influences the pace of learning of students to a large extent. Besides above mentioned strategies a teacher may, therefore, also adopt other techniques, especially for the brighter students for learning concepts of mathematics and in acquiring desired skills. This can be accomplished by developing a healthy relationship between himself and pupils, through proper motivations, by providing suitable educational environment, by providing opportunity for transfer of learning, by meeting the psychological needs of the students, by recognising individual differences, by providing opportunity for creative expression, by using appropriate methods, strategies and skills of teaching, by dividing the learning materials into small steps and the like.

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A Comparative Study of Popular Science Books Published in India and the West

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Popular science books aimed at the young are the need of the hour because science and technology is making inroads into their daily life. Youngsters between 6 to 16 years of age need to be educated about not only scientific and technical knowledge but also its role in the society and daily life. A society using science and technology in a big way without making its young aware of science and technology and its developments is heading for a suicide. The young should know science so that they can cope up with the scientific knowledge taught at schools and with the technological gadgetry that surrounds them at home and other places. It also helps them in understanding the natural phenomena occurring in their surroundings, improve their reasoning and logical abilities, encourage them to try new frontiers and inspire them to take up science as a career. After all, the world of tomorrow will need a science literate society and trained manpower in science and technology for further advancement of the mankind as it tries to develop technologies in harmony with nature, establish space stations in the outer space, and colonise the Moon and Mars.

Today, when all the media—newspapers, television and radio—are not paying attention to educating the young about science, popular science books are the best medium to impart them an indepth knowledge about science and its impact on daily life and society. Says the famous American children's science writer Seymour Simon, "I think it is very important to get kids to read science books from a very young age. If they're not reading books about science by the time they're twelve, you've probably lost them ... Thus if we want a (science) literate citizenry, we have to start children on science books when they're young"[1]. "The doing of science depends or such special human qualities as curiosity, passion, creativity and veracity. Partly because of these characteristics, science has been called the greatest hope of the human race," says another science writer Lawrence Pringle. "Children's books have a vital role to play. They can make science and the universe more accessible to young people. They can stand for and appeal to the finest characteristics and highest aspirations of the human species"[2]

Science popularisation among the

Fellow (August 15 to October 31, 2000) International Youth Library, Munich, Germany masses, particularly among the young, received a big boost in the late 50s in the West, when the Russian satellite 'Sputnik' was launched in 1957. People at large were keen to know the various aspects of space science and technology. Thereafter, leading newspapers in the West began to publish developments on science and technology regularly in their pages. Popular science books were subsequently brought out the need for popularising science for the young was also felt because they were the future citizens. Initially, it was meant to act as a supplementary reading to what was already being taught in classrooms but in due course books on subjects not necessarily oriented to school science lessons were brought out in the West. Similar efforts were made in India when the National Council of Educational, Research and Training was set up in New Delhi in 1961[3]. Initially, writing popular science books was a part-time hobby of science teachers in the West but in the last two decades a large number of leading scientists and science writers have felt it to be too important to be left to them. In India, writing popular science books for the young has still not caught on among scientists except in some Indian languages like Hindi, Bengali, Assamese and Marathi but some science writers have certainly tried their hand at it both in English and Indian regional languages. But now, the question is, how good are Indian popular science books vis-a-vis those produced in the West ? Are there any differences in presentation of science to the young ? What should be done to improve their scope and presentation ?

Criteria for Study

A survey of books and journals on children's literature by experts in the field[4-6] suggests a number of parameters for judging the quality of a popular science book, namely, clarity of presentation, accuracy of the subject, adequately supported crystal clear illustrations, photographs and labelled diagrams, provision of Index and even references for further reading. Besides, opinions of some famous children science writers were also taken into account "Creative science depends crucially upon habits of mind that are most readily acquired by children: curiosity; voracious observation; sensitivity to rules and variations within the rules, and fantasy. Children's books that instill these habits of mind sustain science". says Chet Raymo, Professor of Physics at Stonehill College, U.S.A., and a science writer[7]. Another American science writer Diana Lutz says, "My critical touchstone... is that science writing should be about what scientists do"[8]. She goes on to add that a popular science book should tell a story with a beginning, middle and end; and should "suggest in some way... why most scientists love being scientists". Says the Australian science books critic Eleonor Stodard "It is not possible to teach science without being didactic. After all, didactics is the art or science of teaching. But children's science books can involve the child reader in various ways, so that the child does not receive (science) passively. A young child's involvement is most effective through play, and play can form a part of learning science through books"[9]. "To write about science for children an author needs to know science, to know children, and to know how to write... The role of the writer is to write the book so that a child can feel he is participating in an observation," says Millicent E. Selsam, the science books critic," Good science books should communicate some of the excitement of discovery — and the triumph that goes with the solution of scientific problems"[10]. But while doing this study this writer also did not forget what children's literature critic Patrica Austin said : "the most valuable and important function of children's literature is pleasure"[11] and what Diana Lutz said : "Facts are cheap but enthusiasm is rare". In other words, to inculcate in a youngster enthusiasm about science through a book is more important than all the scientific knowledge put together ..

This author selected about 20 popular science books published in India, some bestsellers, some latest ones and some not so well known ones. He analysed their contents and presentation with the latest books on the same scientific subjects, especially in English, published in the West in the last decade, i.e., 1990s, which were available in the International Youth Library (IYL). Wherever the same scientific subjects were not available in the IYL library, the books on similar subjects or in non-English languages or published earlier were studied.

Science

Although science is taught and thrust down the gullet of young people in schools, very few understand what it is, what role it plays in our lives, and its impact on our society. Often, no efforts are made by teachers or parents to teach the young about the method of science, that it is not simply facts and figures that make science, and that it needs curiosity about the world and is based on observations and hypotheses. The young become aware of science and its implications in society much later in their life when they had already given up science — and sometimes not even throughout their life! To bridge this gap, Dilip M. Salwi wrote *What is Science* (published by Rupa & Co., New Delhi, India, 1993, pages 220) aimed at the young about 12 and above. In form of a dialogue between a science journalist and 12 year old Romi it is *a tour de force* through the world of science. Romi is introduced to science, its theories, laws and hypotheses, how they are created and tested in laboratories, how scientists do research, how they search for new questions and try to find answers to them, how new research work is introduced to other scientists through journals and conferences, and finally how scientific knowledge reaches the public. The book then touches upon how different technological products are created in laboratories on the basis of scientific knowledge. It also deals with how science affects society, how efforts are being made to bring science to the public through various media, and why some people are even starting anti-science movements all over the world. In big readable typography, with cartoons by C.M. Salvi and important statements about science in bold letters, the book gives a total picture about science which a modern young reader should know.

The other Indian book on science, *Vigyan Kya hai ?* is written in the Indian language Hindi by Vinod Raina and D.P. Singh (published by Eklavya, Bhopal, India, 1996, pages 16). With the same title as the previous book, it gives a flavour about what science is all about in form of a story of a king. The king has a son who always asks questions which he himself is unable to answer. The king asks his royal adviser to satisfy the curiosity of his son. The adviser calls for an elephant and four blind men. In front of the inquisitive prince, he asks the blind men to examine parts of the elephant and tell what they are. All the blind men give different answers based on their investigations, reasoning and deductive logic. In the process the method of science is introduced to the prince or for that matter the reader of the book. With typically Indian, black and white drawings by Satyanarayanlal Karne, the book is a good attempt to give an insight into science to a rural youngster.

The two Indian books attacked the issue of what is science directly. In other words, they explained what is science, one by giving details about the scientific process and the effect of science on society and the other explained what is science by means of a story. Here are two western books — the only ones dealing with science as a subject found in the IYL library — which deal with what is science indirectly. The first is the famous American science writer Roy A. Gallant's *A Young Person's Guide To Science — Ideas That Change the World* (published by Macmillan Publishing Company, New York, USA, 1993, pages 225). "The book is intended to broaden and strengthen what may be a foggy understanding of certain fundamental scientific ideas," says Gallant in the Preface to the Book, "Without a sufficient understanding of those ideas we risk having to sit by passively while others make up our minds for us about matters that can change our lives. Whenever that happens, we should have the uneasy feeling that in some small but important way we have lost a measure of control over our lives". The book is basically in form of questions and their answers. It starts with 'How science works and how we use it' and goes to various important questions about the living world, the environment, human organism and behaviour, the physical world, and finally to Science and human values.

Gallant starts from the very beginning of science, how it began in Greece, and how observations, experiments, hypotheses and theories have become a part of the scientific process and how science is different from psuedo-science. After discussing several questions that puzzle a youngster — and questions which are important for him to know in this modern world — he discusses in the end the effect of science on society and how important it is to know science because it is affecting us in all walks of life. Today, every public issue, whether it is water, pollution or nuclear energy, concerns all of us, and everybody should know its fundamental science lest it endangers our life one day. With a few illustrations and more emphasis on text, Gallant's book is a serious attempt at making the young above 12 scientifically literate.

A similar but much more entertaining effort than Gallant's is Jerome A Luine's *Science Mysteries* (published by Lowell House, Chicago, USA, 1995, pages 80). The very title makes one curious about the book. Besides, the way the entire book is designed with interesting illustrations by Wesla Weller makes it a much more inviting book for a youngster. This book is again a series of questions and answers in science but interspersed with catchy titles, cartoons, fascinating facts and figures, and box items and bars on side issues. The book also deals with how science is done as some interesting questions about subjects, such as, the universe, the living world and the human body, are discussed. In other words, the questions are highly selective. Perhaps, only the more interesting ones have been selected. Moreover, unlike Salwi's or Gallant's book, this book discusses the subject in a much lighter vein. An Index on the contents completes the book.

History of Science

Everything has a history behind it. Unfortunately, few realise this despite the heavy dose of history lessons during schooling. History of science is another much ignored subject in schools in India and elsewhere. Youngsters grow up knowing hardly anything about the history of science or technology. Monisha Bobb's *Bullock-carts and Satellites–the development of science and technology in India* (published by National Book Trust, New Delhi, India, 1985, pages 64) is a pioneering attempt at introducing the history of science and technology in India to a young reader about 12 years of age. After a brief introduction to modern India, the book traces the history of science in the land to the Indus valley civilization, its standard weights and measures and its excellent geometry used for designing temples, cities and towns. It then goes to the Vedic times when some great Indian scientists like Susruta, Charaka, etc, contributed to medical science and to the Gupta times when science and mathematics flourished and great names like Aryabhata, Brahmagupta, etc, arrived on the scene. The medieval times were the days of chaos in the country when in some pockets only science survived. Sawai Jai Singh built a chain of astronomical observatories and Bhaskara developed algebra using the new invention 'Zero', and so on. When the Britishers came, they brought the modern science to the land. Indian scientists like J.C. Bose, C.V. Raman, M.N. Saha, S.N. Bose etc, made important contributions to science. After the Independence of India, science was planted systematically by setting up a chain of laboratories and institutes all over the country. Today, modern India's strength lies in the indigenous development of science and technology. With cartoons by India's leading cartoonist R.K. Laxman and good black and white photos, the book is a good introduction to the subject to a young reader.

Zero is an Indian invention. Today, the development of entire science and technology is based on that single invention. Dilip M. Salwi's *Story of Zero* (published by Children's Book Trust, New Delhi, India, 1988, pages 32) is a small attempt to give everything about zero in a story form for a young reader above 12 years of age. Starting from Indian number system and the usage of zero in daily life, the book goes on to its creation by an Indian accountant. In fact, zero was present in other civilizations too but it was only in India that it was treated like a number. It was indeed as Indian genius who assigned a number to nothing. Zero's presence developed number system and algebra. Arab mathematicians came to India to learn this new mathematics and wrote about it in their books. As this mathematics was easier and quicker to perform, it caught the attention of the European mathematicians, too. From the Sanskrit *Sunya*, it became Arabic "Cipher" and then from Spanish 'Zephr' it became 'Zero'. European crusades further spread zero to Europe. Thereafter, science and technology developed in Europe. With two colour illustrations by Ruma Sharma, the book gives the creation of zero and its spread all over the world, leading to the developments in science and technology.

Lastly, Dilip M. Salwi's *Folktales of Science* (published by Rupa & Co. New Delhi, India, 2000, pages 187) is a collection of interesting, curious and amusing tales about well known scientists from all parts of the world. All the scientists are given in the book in an alphabetical order, with the year of their birth and death and an introductory line about them, interspersed with cartoons and portraits of some of them. The book gives either some authentic stories involving the scientists and/or some peculiar characteristics about them. The book gives more emphasis on the human side of their character which is less known to the young rather than their scientific contribution. The idea behind writing the book is to present scientists as human beings with their own follies and foibles which are often not highlighted anywhere but are highly interesting to read. Besides, if science teachers could lace their lectures with these stories they will enliven them and may create interest in the science itself.

Now consider some western books on the history of science, technology, mathematics and medicine and the biographies of some great scientists and inventors. Geoff Endacott's *Discovery and Invention* (published by Viking, New York, USA, 1991, pages 72) is a part of the series 'Strange and Amazing worlds'. A large format fully illustrated and multi-colour book, it focuses essentially on the history of inventions and discoveries, with some biographies of scientists and inventors to boot. Every two facing pages are devoted to one subject in addition to the introduction, some of the interesting highlights of the subject are given in Fact file, and some briefs or photographs about some aspect of the subject in the same pages. For instance take 'The revolution of the earth'. The subject is first introduced, then some details about Galileo Galileo are given, then some facts about Galileo as well as a photograph showing rotation of earth are given. In 'The story of photography', a brief history of photography is given along with the photograph of the first camera, a satellite photograph and a time-lapse photo of a humming bird, in 'Fact file' some tit-bits about the history of photography are mentioned. In 'Technology in the Home', some history of gadgetry at home is first introduced, photos of some gadgets are then given with detailed captions and finally the Fact file gives some main highlights of the subject. In other words, the book touches upon several facets of the subject and gives much of the historical information through tit-bits and photographs. The titles are catchy and much research has gone into selecting photographs of inventions. Wherever required, sketches and illustrations have been added to explain a concept. The book ends with an Index and a Bibliography.

The Story of Illness and Getting Better (published by Watts Books, London, UK, 1993, pages 32) is a curious book on the history of medical science in the West. It takes the help of cartoons, sketches and comic strips to illustrate the history. Of course, there is no lengthy text to tell the story. The entire history is given in form of tit-bits. Two facing pages are devoted to one theme in the history of medicine. Take for instance, 'Coughs and Sneezes'. It first gives some facts and figures on how coughs and sneezes transmit infectitious diseases through germs, how Louis Pasteur showed that germs cause disease, how infectitious diseases have played a part in moulding the history of the world, and so on. The book is not restricted to the confines of the history of medicine but touches upon its most interesting and sometimes hilarious aspects. It is indeed a fun way of knowing the history of medicine. The book may not exactly educate a young 12 and above about the subject but would impart him a feel about the subject and may even excite his curiosity to know more about it. And that is perhaps the purpose of a popular science book.

Denise Schmandt-Besserat's *The History of Counting* (published by Morrow Junior Books, New York, USA, 1999, pages 45) has a very strong pictorial presentation rarely found in books on mathematics. It contains almost painting-like illustrations by Micheal Hays. All the illustrations are based on considerable research done by its archealogist author. But unfortunately, due to his scholarly background, the book is not equally appealing in the text. It describes the slow and gradual development of counting as the need for numbers increased with the rise of various civilizations. It is interesting to note, for instance, how numbers were given different names for counting different things in some civilizations, how various parts of the human body was used for counting numbers in some civilizations, how the absence of zero created problem in the development of numbers, etc. Strange enough, the scholarly author however gives a passing reference to the number system developed in India and the invention of zero. Some concepts of the number system are explained in details. The book ends with a 'Glossary of terms' mentioned in the book.

Leonard Everett Fisher's *Marie Curie* (published by Macmillan Publishing Company, New York, USA, 1994, pages 28) is a slim, fully illustrated book on that great physicist of the world. To be frank, it is a picture book of a sort, with the black and white painting-like illustrations drawn by the author himself. In large format size, the book first gives a chronology of events in the life of Marie Curie and a map of Europe showing her place of birth. The entire book is in form a story of the life of the physicist and each interesting event in the story is supported with a painting. Starting from the birth of Marie Curie, the book tells about how she saved her teacher from persecution at the hands of the Russian regime, why she left her beloved country Poland and shifted to France for higher studies. At Paris, she met Pierre Curie and married him. Thus began their joint research into the newly discovered subject of radioactivity. Subsequently, she discovered radium after much toil in a shed. The Nobel Prize was awarded to her but she continued research relentlessly. During the World War, she even worked at the frontier in order to save wounded soldiers by using her discovery. She died due to overexposure to radium. The book beautifully highlights all the important events of her life both through easy text and illustrations. For a youngster above 12, it brings all the scenes from the life of the physicist alive.

Emma Fischel's *Alexander Graham Bell* (published by Frankline Watts, London, UK, 1996, pages 48) is a part of the series 'Famous Peoples, Famous Lives'. It is again a sort of picture book in which the author has amply used cartoon-like sketches to illustrate the life of one of the greatest inventors of the modern age. Addressed to a youngster of 6 and above, it also covers all the important events in the life of the inventor of the telephone from the time of his birth to death. In bold type face, short sentences and even dialogues of the people who played an important role in the life of Bell, the book gives a nice introduction to the great inventor. It ends with 'Telephone Trivia' which gives the latest developments in telephone and how they have revolutionized our lives and 'Some important dates in the life-time of Alexander Graham Bell'. The entire presentation is like that of a fun book.

Astronomy

The night sky is more or less the first thing that fascinates a young mind. The twinkling stars, the slowly moving planets, the waxing and waning Moon, the 'falling stars', etc. are the first objects that attract him, provided of course pollution has not already obscured the sky. Astonomy is therefore a subject of great interest to the curious young people. They are keen to know all its mysteries. Indian science writers have also not been much behind the western ones in writing books on astronomy for the young. In fact, India's most famous astrophysicist Jayant Narlikar has tried his hand at bringing the mysteries of the universe at the level of comprehension of a young Indian through his '*A Journey Through the Universe*' (published by National Book Trust, New Delhi, India, 1986, pages 64). It is a quick, straightforward journey through the various interesting aspects of the universe, beginning with some historical background and different types of telescopes that have helped in unravelling its various features. It then goes to the brightest object in the sky, the sun, the stars, their formation, our galaxy, the Milky Way, and finally quasars and pulsars. It also touches upon some of the turning points in astronomy, such as, the revolutionary works of Nicolaus Copernicus, Harlow Shapley, S. Chandrasekhar, Jocelyn Burnell-Bell, etc. Sudhir Dar's cartoons try to lend humour to this serious subjects but do so only peripherally. A large variety of black and white sketches and photos further add some charm to the book.

Dilip M. Salwi's *Meet the Planets* (published by Ratna Sagar P. Ltd.. Delhi, India, 1995, pages 74) is, on the other hand, a travelogue of a 12 year old boy Romel through the solar system. He meets one planet after another, talks with them, shares information, and also comes to know how different they are from each other. Supported with cartoons by India's famous cartoonist Ajit Ninan, black and white illustrations by Sujasha Dasgupta and Vandana Bist, and also photos, the book introduces the planets through interactive dialogues. Essentially a dream sequence, it begins with a class on astronomy in which the teacher gives some idea of the solar system but Romel is not satisfied and is keen to know more. He reads some illustrated books and dreams of visiting the planets. In a dream the same night, he meets the planets, including the earth, one by one.

Jean-Pierre Verdet's *Earth, Sky and Beyond - A Journey Through Space* — (published by Lodestar Books, New York, USA, 1993, pages 44) is an original French book translated into English, with illustrations by Pierre Bon. It is a fully illustrated book; one can even call it a 'picture book' on astronomy. Interestingly enough, the book starts with acquainting the young reader with the concept of height. How much high is the poplar tree, how much high a bird soars, how much high an aeroplane flies, how much high a satellite circles the earth, etc., and then goes on to tell about how far away from the earth are the Moon, the planets, the Sun, the stars, and other objects in the sky. In passing it gives some interesting features of that heavenly object and some historical episode to excite the reader's curiosity. The book ends informing the young reader that various questions about the universe are still unanswered. Bon's beautiful colour drawings of heavenly bodies in the backdrop of stars add further magic to the book. The book however, remains simply an introduction to the fascinating subject and is perhaps meant only to do so. The author's sole purpose in writing this book is to excite the curiosity of the young about heavenly bodies. In large picture book format, it is addressed to six to ten years olds.

Astronomy by Kristen Lippincott (published by Dorling Kindersley Publishing Inc. New York, USA, 1994, pages 64) is again a pictorial book on the subject but its audience is the young people above 12 years of age. A fully illustrated book, with colour photos, sketches and even labelled diagrams, it is a treat for any youngster and even an adult. In every two facing pages, it takes up a subject and deals with it in small briefs, historically and scientifically, with all the relevant pictures. At places even experimental details are mentioned. Take for instance, the pages on optical telescopes. The book gives brief details of the old telescopes, then goes to some of the telescopes that made history and finally the latest ones, such as the Multi-Mirror Telescopes. It also gives briefs on how cameras are used in tandem with telescopes, how telescopes are built, and distances to stars are measured using telescopes. Similarly, all the planets are discussed one by one, with the history of their discoveries, their astronomical, meteorological and geological details, visits of spacecraft, latest photos of their surfaces, etc. Without very many words, the book gives a clear-cut idea about various heavenly bodies and clarifies the basic concepts about them with the help of pictures and labelled diagrams. The experimental part dealing with instruments, observations and methodology, which is often missing in most of the books on the subject, is also taken care of in the book. An index completes the book. It is certainly an ideal book for any young astronomy fan. A part of *The Eyewitness Science* series, the presentation certainly excites the curiosity of a youngster. The book is a collaborative effort of several experts in their fields.

Oceanography

Ocean exploration is one of the frontier areas of science. Awareness about oceans as a source for food, energy, mineral resources, medicines, etc. is new to the mankind. Efforts are in progress to make the public aware of the tremendous possibilities that oceans offer to the mankind because about two-third of the surface of earth is covered with sea water. Books on oceans especially aimed at the young have appeared in recent times both in India and the West. Jagannath Mohanty's *Wonders of the Sea* (published by Children's Book Trust, 1993, pages 52; illustrated by Chaitali Chatterjee and cover by Viky Arya) is a pioneering effort in this direction. With a beautiful, colourful cover, the book touches upon the various aspects of oceans from their formation, waves, tides, currents, colours, etc., to their plant, mineral, animal and fish wealth. Their potential as a source of energy is also highlighted. Clear, two-colour line sketches of formation of oceans, their animal and plant life support the text. However, the emphasis is more on the animal and fish life living inside the oceans. The book ends with a word of caution about over-exploitation of oceans.

A similar book which covers the same subject more extensively was brought out by the same publishing house three years later! It is *Call of the Ocean* by T. Pakshirajan (published by Children's Book Trust, 1996, pages 104, illustrated by T. Karthikeyan). It received the Second Prize in the Competition for Writers of Children's Books. The book deals with all the aforementioned areas but the subject matter is much more appealing for the young readers above 12 years because it also gives sidelights as well as interesting tit-bits about it. Indian efforts made in fishing, mineral exploration, energy extraction and even Antarctica exploration are mentioned in the book. Tapping icebergs for water is also included. With excellent line drawings to support the text, the book is a thorough attempt at giving an overall idea about oceans and the potential they hold for the mankind in this millennium.

But these Indian books, though packed with all relevant information, lack the necessary visual and experimental support for the science explained in them. The case in point is *Oceans* by Andrew Haslain and Barbara Taylor (published by Two Can Publishing Ltd. in association with Franklin Watts, London, 1997, pages 48) published in the series *Make it Work*. First of all, the text is very short and crisply written. The interest in the subject is created more due to the visuals rather than the text. In the Indian books, the text is roundabout though it is interspersed with interesting tit-bits of information. Secondly, some scientific concepts about the oceans are explained by means of simple experiments which the young people can do at home. This experimental support makes the young reader feel at home with oceans. It makes him feel that though ocean is so vast and awesome all that is happening inside it is based on simple everyday science. It therefore increases his confidence in learning the subject. Moreover, in this book, the authors have resorted to plaster-of-paris models and paper collages to clarify certain ideas about oceans. Besides, the book deals exclusively with the various geological phenomena that led to their formation and that even today occur inside them. It does not deal with marine life at all. An Index and a glossary at the end of the book enhance the value of the book so that any subject can be referred to easily. The book is again a collaborative effort of several experts.

Another ideal book on oceanography for the young above 12 years old is Dr. Philip Whitfield's *Oceans* (published by Viking, London, UK, 1991, pages 72). Brought out in the series 'Strange and Amazing Worlds', it is yet another pictorial treat on the subject. The book takes a subject and discusses it with minimum words, photos and even labelled sketches in two facing pages. In addition, a 'Fact file' is mentioned, which gives some interesting and amazing information about the subject under discussion. In addition to geological, oceanographic and marine biological details about the oceans, the book also gives some interesting aspects of the man's quest to know more about oceans and about his efforts to tap its energy, food, medicine and mineral potential. An Index and a short bibliography enhances the value of the book further. No doubt, the author, a medical researcher and teacher, knows the correct blend of scientific information and illustrations for a young reader. He has already won the Christopher Award for his previous book on whales. Nevertheless, a team has worked behind the excellent production of the book.

Environment

Environment has become a concern of one and all in the last two decades because of growing pollution and several ecological disasters and have occurred in different parts of the world. Earlier, birds, animals, plants, ecology, landscape, etc., were seen in isolation. In fact, if one looks at the history of writing on popular scientific topics, birds, animals and plants are the first ones to be written about for the public consumption and the young (12). It is in recent years that birds, animals, plants and ecology are treated wholistically as one — categorised as 'environment'. It is now believed that 'one aspect of environment cannot exist without the other. Several environmental movements have started all over the world with the pioneering efforts made by the Greenpeace at the political level in Germany. Obviously, the need for highlighting environmental issues arose in the media. Several science writers actively took up the task of making the public aware of various environmental issues. In India, environment as a subject has even entered the classrooms and several textbooks on this subject, aimed at school-going young, have been produced. Several popular science books explaining the various aspects of environment to the young have therefore also appeared in the market.

In India, several environmental movements have started but none so popular and successful as the *Chipko* movement in the Garhwal Himalayas. Considerable information about the movement has appeared in the Indian press and its crusader, Chandiprasad Bhatt and Sundarlal Bahuguna, have become household names. Although this author has written the biographies of these crusaders in one of his books on environmentalists, *Chipko* written by a team headed by the famous Indian playwright Feisal Alkazi (published by Centre for Science and Environment, New Delhi, India, 1993, pages 32) is the first book that gives a dramatic presentation of how the Chipko movement was started, how it gathered momentum and how it is sustained over the years. The entire book is based on real incidents involving real persons and tells the story of the Chipko movement in form of dialogues and situations. Chipko in the Indian language, Hindi, means 'hug'. The entire movement centres on the concept of hugging trees to save them. When heavy rains in the Himalayas brought in floods, destroying lives and property, local people began to wonder what were the reasons for this misery. Crusaders like Bhatt went from village to village and urged the people to save the trees because their misery could be traced to their destruction for the wood on a large scale by the local contractors . Particularly, village women and children joined hands and stopped the destruction of forests by individually hugging the trees and not allowing the contractors to destroy them. The aforementioned book brings forth the entire air and colour of the movement through the actions and words of ordinary village folk who made it a success. Sketches and colour illustrations further lend air of the local milieu of the Garhwal Himalayas. An activity sheet at the end of the book makes a young reader think further about several issues concerning trees and forests. The book may not exactly inspire an urban 12 year youngster to take up the cause of forests, but it provides enough material for school teachers to base small skits and play on it for further propagation of the environmental movement.

Judi Friedman's *Operation Siberian Crane — The Story Behind the International Effort to Save an Amazing Bird'* (published by Dillon Press, New York, USA, 1992, pages 96) is a similar book on a crusade to save an endangered species of bird, the Siberian crane or 'Sibes'. It tells the story of an international effort in a chronological order from the moment its two American founders, Ron Sauey and George Archibald, met and set up the International Crane Foundation in a horse farm in Wisconsin, USA, how they made efforts to search for the nesting grounds of the cranes in Russia, China and India, how the eggs were collected from marshy areas and brought to the USA despite all kinds of transport and bureaucratic problems, how scientists from different countries willingly collaborated in this novel venture, how ordinary people helped scientists locate the nesting grounds and how scientists tried to educate people including hunters, about the value of the birds, how the population of the birds has risen both in the wild and at the Foundation, and how the saved cranes have responded to their conservation; and so on. It is a story of success and frustration which were met at every step in this novel venture. And today, despite all the efforts being made to save the Sibes and the awareness about their endangered status being made in the countries over which they fly, their fate hangs precariously in balance. Nevertheless, it is a gallant story interestingly told with touches of emotions of the concerned scientists and with beautiful colour photographs of birds and scientists. The book is aimed at the young above 12 years of age who are likely to be inspired to take up similar crusades elsewhere in the world. With a chronology of events glossary, bibliography and an index at the end, the book can serve as a guide for further study of the birds. The author has talked to several experts in the field to write this book.

Stephen R. Swinburne's *Once A Wolf—How Biologists Fought to Bring Back the Grey Wolf* (published by

Houghton Mifflin Company, New York, USA, 1999, pages 48, photos by Jim Brandenburg) is another nicely written and colourfully illustrated book for the young about 10 plus which tells the story of the efforts made to save the grey wolf from extinction in the wild. It begins with the prejudices about wolves that have been with human beings for ages. The wolf has been shot on sight in the West because it harasses and kills cattle. In fact, wolves have been systematically exterminated in various wild life sanctuaries and even national parks because of the fear of their menace to other animals. But in the last few decades, some scientists, who had studied the wolves in the wild, found them not to be deserving this ill treatment. Wolves sing together, hunt together and even bring up their babies like human beings do. A group of conservationists therefore campaigned to save them and preserve them for the posterity. Using satellites and latest telecommunication methods, wolves have been tracked and studied. Today, the territory of wolves in the wild is on the rise in the West. The book skillfully highlights the efforts of scientists and the beleaguered future of the wolves.

Another similar book is *The Chilika Lake Adventure* by Shveta Kalyanwala, Feisal Alkazi and Martha Farrell (published by Centre for Science and Environment, New Delhi, India 1997, pages 48). Written in a story format, with dialogues and situation, the book is meant to inspire young readers about 12 years of age to take up the cause of environment. The story is about a school teacher who gives up her job to save Chilika lake in Orissa, India, from further pollution by industries. Her action inspires her students, a girl and a boy, to follow her to the lake and join hands with her in the cause. The students make friendship with the local people and join them in their demonstration against the industries. In the process, they come to know about the status of the lake, its flora and fauna, and how the local people are dependent upon it for their livelihood and how industries affect their lives. With beautiful colour drawings to support the text, the book would go a long way in inspiring the young above 12 to take up any environmental cause, which could even be their backyard pond.

Dorothy Hinshaw Patent's *Children Save the Rainforest* (Cobblehill Books, New York, USA, 1996, pages 44) is, on the other hand, a book about a rainforest in Costa Rica saved by the young. The book, unlike the Indian one, gives a straight-off-the-shoulder idea about the rainforest, the feel of the place to the young readers, the kind of plant and animal life that lives in it, their importance for scientific study, their medicinal value as well as their need for the survival of the mankind. With beautiful colour photographs by Dan L. Perlman, the book gives a panoramaic view of the rainforest, with some box items on the exotic life living in it. The description of the forest is in so much details that one feels as though one is walking through it. The book concludes by giving some details about how the local school youngsters became aware of the need for protecting the rainforest, how they joined hands with environmental bodies, collected funds and then hired forest guards to save the rainforest. Unlike the Indian book, this well produced book makes the youngster aware of the importance of rainforests and the need to save them as those school students of Costa Rica had done earlier. In all likelihood, the aims of both the books are the same to inspire youngsters to take up environmental causes. Due to the story element the Indian book is likely to inspire the youngsters more than the western book which gives more emphasis on the rainforest.

Picture Books

A picture book is the one in which the story is told through pictures and the text is merely supportive to the pictures. But it is my personal view that Science picture book is a new concept. In addition to pictures, it has also text, and quite considerable too, for the simple reason that science needs explanation. Simply showing or illustrating something will not do in a science book, be it about a natural phenomenon, instrument, law or theory. And in recent times science picture books are being published in a big way in the West. In India, too, some efforts have been made in this direction. Some sample books are mentioned below vis-a-vis those produced on the same subjects in the West.

Since times immemorial, the universe and all the things that it contains is believed to be composed essentially of four elements, namely, earth, fire, water and air. It is a belief quite common in the cultures of people living in different parts of the world, including India. Dilip M. Salwi took this idea to write a series of picture books called *Meet the Four Elements* (published by Ratna Sagar Pvt. Ltd. New Delhi, India, 1994, pages 16 each) to highlight the value of these elements from environment point of view. Every book is essentially a story about the element and what it experiences in the present milieu in India. For instance, in *Mr. Sun takes a holiday* (the other three are *Madame Air wants a Change*, *Meet the Soil Fairy* and *In search of Water*), the sun decides to take a holiday on a Sunday because everybody on the earth has a holiday. The absence of the sun causes several problems to plant, animal and human life. It becomes very dark and even glaciers come down to cover the earth. When the sun realises his folly, he cuts short his holiday and joins duty. In an indirect manner, a young reader comes to know the importance of the sun for all living beings on the earth. The book ends with some little vital information about the sun. The other three books are on the importance of air, soil and water in our life. Beautifully illustrated in colour by Atanu Roy, the books highlight the importance of these elements indirectly for a reader about 8 years and above.

Mary Hoffman has dealt with the same subject in a more conventional manner in her large format, picture book *Earth, Fire, Water, Air* (published by Dutton Children's Books, New York, USA, 1995, pages 46). She takes one element at a time and discusses the ideas that prevailed about it in different cultures of the world; how every element was revered and considered sacred; how it has become a part of religions, legends and folklores so that everybody knows about it and its value in his daily life. In other words, she has emphasised the symbolic value of these elements for the young readers about 8 year old in the present situation, how it is ignored and exploited today. She has also added at places some scientific information to emphasise her point. Unfortunately, the importance of the elements gets lost in the legends, folktales and even poems mentioned in the book. Had the scientific part been more, with relevant illustrations, the value of the book as a crusade against the misuse of environment would have enhanced. Of course, Jane Ray's beautiful paintings would captivate and hold the attention of many a young reader.

Birds are a part of every landscape and their presence is a good indicator of a healthy environment. They are however given the least importance in the school curriculum. Consequently, Indian writers have also not given much importance to them. *Some Indian Birds* by zoologist Dr N.N. Majumdar (published by Children's Book Trust, New Delhi, India, 1970, pages 58) is one of the earliest books on Indian birds written for the young. It has been reprinted several times since its first publication. Jamal Ara's *Watching Birds* is its only competitor but, then its theme is different, it concentrates more on how to watch birds rather than the birds themselves. To be frank, the book is simply a compilation of physical appearances of some frequently and easily seen birds found in India, their food and nesting habits, their seasonal and mating behaviour, calls and colour of eggs, the differences between males and females, if any, etc. which are of interest to the young. All the descriptions about the birds are supported with beautiful multicoloured illustrations by S. Basu Roy Choudhury and Pranab Chakravarti. It is written for the young about 10 years of age.

Now let us compare this book with Sandra Markle's *Outside and Inside Birds* (published by Bradbury Press, New York, USA, 1994, pages 40) which from its very title makes it clear that the book is not simply about external appearances but the inner body parts of birds. Initially, it appears as though the author intended to tell the young reader how and why a bird can fly while a human being cannot but slowly she goes on to the various other aspects of a bird's life, such as, the shape of their beaks, feet, talons, eyes, etc. She shows that in addition to wings and hollow bones which enable a bird to fly, a bird has specialised beaks, talons, eyes, feet, etc, for survival in the wild. Some titbits, such as, baby birds have egg-tooth to crack open the egg shell, would even enlighten an adult. Besides, the book also contains magnified photos of heart, bones, eyes, feathers, gizzard, etc., of birds. It satisfies the curiosity of a young reader 10 years of age about how birds are different from human beings. Indeed, for modern young reader, this is quite enlightening. The author could have given tips on watching birds which are also missing in the Indian book.

The Indian children's writer Navkala Roy wrote a series of picture books *How It Works* in 1986. She wrote about the working of motor car, television, telephone, aeroplane, clock, ship and railway train in the series. As a sample, her book in this series, *The Motor Car* (published by Children's Book Trust, New Delhi, India, 1986, pages 24) is discussed here. The book starts from a vintage car rally flagged off in 1983 in New Delhi and goes on to the history of the invention of car in Europe. It first goes to the times when every car was individually built and then goes to Henry Ford, who began the mass manufacture of cars in Detroit, USA. How the car works is then tackled with illustrations, its various parts discussed with their working and finally the cars that are to come. The terms like clutch, brake, suspension, horsepower, etc. becomes clear through the illustrations and text in the book. With beautiful cartoons, well labelled diagrams, small tit-bits about cars and catchy titles, the book makes reading about cars enjoyable. It is one of the well written popular science books aimed at the young. The author is essentially a writer for children and has herself learnt about cars by talking to the experts in the field.

Andrew Langley's *Car* (published by Franklin Watts, London, UK, 1987, pages 32) is one in a similar series of books *Spotlight On* published in the West. It is a simple picture book which gives one an idea about cars and some interesting tit-bits about them. It starts with different parts of a car, goes over to different types of cars, then some history of cars, the present status of cars and car accidents, and finally cars of the future. A visual mixture of illustrations and photos. It ends with some car facts, a glossary and an index. In a nutshell, an eight year old comes to know everything about cars through this slim book except how they work. However, Richard Sutton's *Car* (published by Dorling Kindersley, London, UK, 1990, pages 64) — a part of the *Eyewitness Guides* — is a pictorial treat on cars and gives everything a youngster above 12 years old wants to know about cars. Every aspect of a modern car is covered in two facing pages, giving little, crispy details supported with photos or illustrations or even labelled diagrams or models. It begins historically from the first car built in Germany in 1898 to the era of assembly line mass production of cars started by Henry Ford, then to the modern car, its various kinds, and finally the different parts of the car and how they evolved over the century. The book jumps from history to the modern times and the text also jumps from simple information to technical working of cars and their parts. This book is a collaborative effort of not simply an author and an illustrator but of a large number of experts in the subject as well as in art and photography.

R.K. Murthi's *The World of Shadows* (published by National Book Trust, New Delhi, India, 1999, pages 44) is a science picture book which has both the text and pictures explaining science in plenty. The book is about shadows, how they are created, what is their role in our daily life, what is the science behind them and how it is used to determine certain things both about the earth as well as some heavenly bodies. Written in a dialogue form, it is basically a chat between an uncle and his two young relatives. But, unfortunately, there are not enough varieties of novel situations in the book required to captivate and sustain the interest of a 12 years old young reader though it explains science behind shadows alright through the uncle. The two colour illustrations by Neeta Gangopadhyay somehow do not add any additional dimension to the subject. On the other hand, Jane Burton and Kim Taylor's *The Nature and Science of Sunlight* (published by Franklin Watts, New York, USA, 1997, pages 32) is a visually attractive, colour photo-based large format book on sunlight and its effects on earth. It deals with various aspects of sunlight from creation of day and night, seasons, food production to solar energy, rainbows, and the variety of colours produced in the sky due to the terrestrial atmosphere. The book does not go into details anywhere but touches the periphery of the subject, giving some concepts supported with beautiful visuals. Addressed to the young above 10, the book ends with *Things to Do*, a Glossary and an Index of plants and animals, and an Index to the subjects discussed in the book. It is also a result of team effort.

Rekha and Yatish Agarwal's *The Story of Blood* (published by National Book Trust, New Delhi, India, pages 64) is quite an old Indian science picture book aimed at the young 12 and above. Essentially a dialogue between a mother and her daughter about blood, the text boils down mainly to question and answer sessions between the two, with some home work, etc, between the session, and — finally — a visit to a hospital. The subject has been covered very well by the authors, of which one is a medical doctor. First of all, what is blood is discussed, what it contains, how and where it is produced in the human body, then the heart and its functions come under discussion followed by the types of blood, and whether it is possible to donate one's blood to another human being. The illustrations for the book were created in a workshop organised by the National Book Trust. As a result, the book is a *pot-pourri* of a variety of art work and not all illustrations depict the subject properly for a young reader. A book on the same subject was not found in the IYL library for comparison. Kate Rowan's *I Know How My Cells Make Me Grow* (published by Walker Books, London, UK, 1999, pages 30) which is essentially a picture book illustrated by Katharine McEwen was therefore taken up for comparison. To be frank, there is no comparison between the two books. The Indian book is highly pedagogical; the mother explaining the science behind blood in form of a lecture! The British book is, on the other hand, illustrative in nature. Here also the mother gives just an idea of how the body grows due to the growth of all kinds of cells in the body but not in form of a lecture. Beautiful cartoons, including that of a cat, make the book lively and inviting. At no point, one feels as though the mother is trying to teach her son about the growth of his body. The explanation about body growth comes forth very naturally. Of course, this slim book is aimed at the young 6 to 8 years of age.

Finally, Dilip M. Salwi's *My Robot Robbi* (published by National Book Trust, New Delhi, 1998, pages 40) is a novel science picture book effort in India because here for the first time some games, puzzles, quizzes, etc. were included in a book meant for the young about 8 years old. The idea behind writing this book was to captivate the attention of the young readers to the fascinating subject to robot as well as to involve him in some activities. With interesting tit-bits, cartoons and illustrations by C.M. Salvi and dialogues, the effort seemed successful as it is evident from its quick reprint in the next year. In the book, an eight year old boy narrates his experiences with the robot 'Robbi' bought to do domestic chores at home. The robot turns out to be more interesting than he thought it to be. It can sing songs, do any chore as many times as one desires, entertains friends and guests, walks the dog, etc. But it gets unwell when it is hit by a cricket ball! The repairman then tells the boy how a robot works and what are its most important functions for the mankind.

Leonbattista Donati's *Robots — The Story of Tools, Machines and Artificial Intelligence* (published by Franklin Watts, London, UK, 1995, pages 48) is an original Italian book translated into English and published in the 'How Science Works' series. The book is an excellent exposure to the world of robots, both from visual as well as text point of view. Published in a big format, it deals with one aspect of the subject in two facing pages. Very interestingly enough, it starts from man's unique ability to make tools to ease his own work. According to the author, the robot is just one such tool. The book therefore starts from man's efforts to build tools for his work, how he uses his hands, legs, eyes, etc, to perform his work as well as make use of tools. The robot is the acme of this tool building history. Fascination with automatons has also been with the mankind over the last several centuries. The book goes back to various points in history of science when the roots for the creation of robots can be traced. In other words, the book is an elegant blend of history, techniques, science and automatons supported with photos, illustrations and diagrams at every step. It also gives the latest ideas about robots, how they would be used in hospitals and industries and for hazardous jobs in the exploration of mines, oceans and the outer space, and finally it deals with the frontier science subject of artificial intelligence. It ends with a glossary and an index. The book is again a collaborative effort of several experts. It is illustrated by as many as five artists as mentioned on the frontispiece, not to speak of several others who must have done work behind the scene.

Experiments and Fun

Scientific information and knowledge is all fine but the basis of science is experiments and original thinking. Indian science writers realise the importance of experimentation in inculcating scientific temper and interest in science among the young. They have also written books which encourage young people to do experiments and projects. But an Indian youngster has limited resources both at school as well as at home. They have therefore written books on experiments taking into account the materials easily available to them both at home and school. The pioneering effort made in this direction is by Arvind Gupta, an engineer turned science populariser, who has written number of books addressed to an Indian young. *Little Science* (published by Eklavya, Bhopal, India, 1989, pages 68) is one of his early books. Children are eternal explorers. In their free moments, they are always experimenting and improvising, says Gupta in the introduction to the book. The book starts with paper folding which helps a child learn geometry. He comes to know of various shapes such as diamond, pentagon, octagon, cube etc, by using simply a paper and folding it. Then using easily available scrap materials such as postcards, bricks, egg cones, matchsticks, broken bangles and other things, the book tells how the young can make a spring balance, switches, tree name plates, etc. The book ends with the ancient Chinese art of tangram in making a variety of shapes using only seven pieces of cardboard. Certainly, the book inculcates the innovative spirit, the urge for experimentation and helps the young know simple things about science. Gupta makes no effort, or perhaps does not feel the necessity, to give any scientific explanation for projects or experiments that he mentions in the book.

On the other hand, Dipak Kumar Barkakati's book *Doorway to Science* (published by Children's Book Trust, New Delhi, India, 1992, pages 46) gives a detailed idea of what is science all about as an introduction. In fact, he goes step by step giving the young an idea about how scientific knowledge about the world is created through our five senses, how this knowledge is sometimes deceptive unless corrected by instruments and how the tool of logic is used for arriving at some hard scientific facts. He illustrates this by giving interesting stories and examples from the lives of Beethoven, Jules Verne, Ernst Rutherford and others. He then emphasises the role of 'measurement' and mathematics in science, and goes to the various divisions of science, namely, physics, chemistry, astronomy, botany, genetics, space science, zero, algebra, binary system, calculus, geometry, etc. In the end, as a 'Conclusion' he gives some ideas of development in science. He notes that scientists are always exploring new frontiers of science but whatever they say or claim may not necessarily be right; it needs to be checked and double checked.

Let's see how two British and three Canadian authors have tackled this subject of experiments and projects in the respective books. *Light and Wrong* is no. 7 in the series of books called *The Spark Files* by Barbara Allen and Terry Deary (published by Faber and Faber Ltd, London, UK. 1999, pages 83). To be frank, the book is simply fun but with less emphasis on experiments and more on the story. It is a story set against the background of some UFO sightings of two boys, Sam Spark and Simon Spark, with their dog Boozle, who encounter the alien Bluto from Pluto while all around them people, including their teacher, Mr Planck, are looking for UFOs in the sky! It is the hallobalo about the UFOs that keeps the story moving. Besides, the most hilarious and comic situations created in the story make the Spark boys and their dog lovable characters. There are however only eight experiments mentioned in the book which deal with some very simple concepts, such as, light travels in a straight line, how light bends in a glass of water, how to build a periscope and a thauratrope. Comics and cartoons further add spice to the story. What is the age group the book is addressed to is not clear because the text is addressed to a 12 year old and the experiments would interest those below 10! The book makes the point very clearly that science is not something very serious and is a part of every day life, which none of the Indian books makes and the Canadian book mentioned below makes it rather more systematically and rigorously.

Sign Out Science — Simple hands-on Experiments using Everyday Materials (published by Pembroke Publishers Ltd, Ontario, Canada, 1993, pages 127) is authored by three science teachers, Silvana Carletti, Suzanne Girard and Kathlene R. Willing on the basis of their experiences of portable science activities in bags evolved by them for various school students. According to the educationist Allan MacKinnon in his 'Introduction' to the book, it reflects a recent movement in educational thought that connects children's lives in elementary school with a much experiential and cultural base—that of the family. In short, the book is a novel attempt at allowing parents, teachers and students to work together in various scientific experiments. In the beginning, the authors give the background in which the entire concept of activities was developed and carried out in schools. Much emphasis was laid on connecting scientific information and knowledge to the skills required to do the activities, which enables a student to go further into the subject, a factor often missing in most experiment-oriented books and the aforementioned ones too. The book also emphasises that it is not simply scientific knowledge that make new discoveries or technologies but several other qualities of an experimenter, such as, perserverance, cooperation, consideration for others, thoroughness, concern for accuracy, etc, that go into the making of a scientist. Then follow the bags of experiments, such as, on the swing of pendulum, apple juice, acid snow, germinating seeds, etc. Each experiment is divided into five parts : 1. *For your information*, gives the basic background of the experiment; 2. *Materials needed*; 3. *Words to know*; 4. *Now* *try this*, gives instructions on what to try; 5. *Look for these*, gives a list of books which the student can refer if he is interested to go further into the subject. In other words, this book gives the total picture of how an experiment is to be performed, its importance in daily life, and its implications in creating new technologies. The book ends with various activities such as school level science fairs, Science Olympiads, etc that a teacher can perform taking the parents of students into confidence. Certainly, a serious and systematic effort on the performance of experiments in schools as well as homes.

Now, a look at three American books on experiments clearly shows that the idea behind writing them is to make experiments look like fun to the young. The titles, subtitles and the covers are all inviting. Jim Wiese's *Roller Coaster Science — 50 wet, wacky, wild, dizzy experiments about things kids like best* (published by John Wiley and sons, New York, 1994, pages 113) is a collection of experiments about some things which youngsters encounter in daily life, such as, a cycle, a garden swing, a gyroscope, a jumping toy, a roller coaster, etc., and enjoy them but take the science behind them for granted. Through the experiments performed on these things, he would come to know the science behind their working. For instance, what is a slide in a park is first discussed, then the activity associated with it in a step by step procedure, and finally the scientific explanation is given. Some variants of the same activity are discussed in separate box items. At places, the history of certain things or some interesting sidelights about them, such as, amusement parks, frisbee, solar energy, etc, are also given so that the young reader also imbibes some additional knowledge. This book aimed at the young above 10 years ends with a glossary of scientific terms mentioned in the book, a bibliography of books for further experiments, and an index. In performing the experiments mentioned in this book, the author took the assistance of several school students and teachers.

Bernie Zubrowski's *Balloons—Building and Experiments with Inflatable Toys* (published by Morrow Junior Books, New York, USA, 1990, pages 80) is one of the series of books written by the author based on the experiments performed by fifth graders of a Boston school. Balloons fascinate a youngster from a very early age. So, naturally a book containing activities involving a balloon will certainly be liked by the young about 6 to 10 years old. Moreover, as one flips through the book, one feels the fun a youngster would have from the way Roy Doty has interspersed the text with his lively sketches, cartoons and illustrations. How balloons can be used to illustrate their different kinds and capacities and how their air power can enable them to move like aeroplanes, trains and even ships, are playfully discussed in the book. The materials needed for the experiments are also easily available in a household. The book gives a step by step procedure for the performance of an experiment after giving an introduction to the subject and the materials required. Scientific explanation of the experiment then follows. The book is 'A Boston Children's Museum Activity Book'. In other words, the museum has sponsored or supported the publication of the book, a healthy sign which need to be emulated by museums in other parts of the world.

Finally, the ideal experiment and fun book is *The Science Explorer Out and About—Fantastic Science Experiments Your Family Can Do Anywhere!* (published by Henry Holt and Company, New York, USA, 1997, pages 127) by Pat Murphy, Ellen Klages, Linda Shore and the staff of the Exploratorium at San Francisco, USA. The book tells how to perform some simple experiments that explain much of the science happening around a youngster between 6 to 10 years of age. The beauty of the book is that, apart from being well illustrated and user-friendly to a youngster, it is also aimed at parents who can act as guides for several experiments mentioned in the book. In fact, the authors have clearly marked experiments which can be done by a youngster alone, those which should be done in the company of his parents, those which need long term planning,, those which need more young people to perform it, those which need only household materials, those which need material from the local grocery shop, those which can be done at home during a rainy day and those which can be done on a bright, sunny day! In large format, with large typography and illustrated with photographs, cartoons and illustrations, the book goes step by step through the experiments, starting the 'What do I need?' to 'What do I do?' and 'What's going on?' Some tips on science seen in daily life are given wherever possible. Wherever needed some relevant photographs and more details about a subject concerning an experiment are also given. The book ends with a bibliography of book on more advanced experiments, a note about the exploratorium, and exhaustive index. Several scores of families have been thanked at the end of the book for participating in various experiments mentioned in the book. No doubt, such a book can only be written with the help of several experiments and with facilities available in an exploratorium

How Indian Books are Different ?

Nothing happens in isolation in a society. So it is with popular science books. Books particularly reflect a society's educational system, culture, values and ethos. Indian popular science books therefore reflect the Indian society's science education system, culture, values and ethos. Of course, it does not mean that there are no exceptions to the rule. There are exceptions in popular science books, too. There are some Indian books which have not towed the line. Some writers and publishing houses have tried to bring out books which have to say something other than what the Indian science educational system demands or expects them to. In this context, the books meant to inspire the young to take up environmental cause.

namely, 'Chipko, and 'The Chilka Lake Adventure' brought out by the Centre of Science and Environment are exceptions because environment is being ignored in all Indian cities, towns and villages in the name of development and progress. Similarly, Arvind Gupta's small books on science experiments which could be performed using materials available in Indian homes are exceptions because the entire science educational system discourages experimentation even in classrooms!

One clear inference can be drawn from the above discussion on Indian vis-a-vis western books is that, the latter are more visual orientated, contain less verbiage and gives more emphasis on conceptual understanding rather than simply scientific facts and figures. Besides, Indian books do not contain any indexes or references for further reading. Some science writers, particularly Dilip M. Salwi and recently R.K. Murthi, have tried to overcome this general tendency by giving science facts and figures in a more friendly, story-like manner. But, then, weaving scientific facts and figures into a story is not an easy task and requires considerable skills on part of the writer. Perhaps, it required the calibre of a playwright of the stature of Feisal Alkazi to dramatise the events mentioned in the two books 'Chipko' and 'The Chilka Lake Adventure' through dialogues and situations.

The second clear inference is that Indian books are more dependent upon artists who have to draw correct draw[illegible]gs of scientific equipment, phenom[illegible], scientists, animal and bird life, etc. Apart from being ill paid for the job, most Indian artists are scared of science and do not want to experiment with scientific illustrations. As a result, drawings are often stereotyped 'not suiting the spirit with the scientific explanations given in the text. The western books, on the other hand, are much dependent upon real colour photographs. They also use sketches, illustrations and even labelled diagrams to explain a scientific concept. Some have even resorted to plaster of paris models and paper collages to illustrate a concept! Naturally, considerable effort and thought has gone into the selection of the visual material.

Thirdly, Indian books except 'My Robot Robbi' and 'The World of Shadows' do not contain any supportive experiments, activities or any ideas which a young reader can try himself. The basis of science is observation and experimentation. If this is ignored, how can a youngster's interest in science be sustained ? Simply passive reading of science will not do. According to Barbara Elleman, Editor, Booklinks, "Interactive approaches are probably the biggest trend in children's books. If I had to choose one word to symbolize what is new in the children's book world, interactive would have to be the word of choice."[13]

Fourthly, some Indian writers have resorted to creating situations or stories to explain science, namely, 'Meet the Planets', 'The Story of Blood', 'The World of Shadows', 'Mr Sun Takes a Holiday'. It is certainly the most attractive way of explaining science because the young reader feels that he is participating in the event. No western books have tried this technique in so far the books this writer could lay his hands on the IYL library. Quite likely, this technique is very risky. If the story or situation appeals to the reader, it is fine. Otherwise, the reader will give up the entire book.

Fifthly, Indian writers tend to present everything that they know of or have done research into the young reader. 'Call of the Oceans', 'Wonders of Oceans', 'What is Science', 'Journey Through the Universe', are illustrative of this tendency. Western authors do the same thing in a different manner by giving the side issues in box items or ignoring them altogether. The illustrative nature of their books enable them to do so more effectively. But their emphasis is more on a narrow subject rather than a broad one. This type of presentation also helps the young who 'graze' rather 'read' a book. The young can therefore have small tit-bits of information on whatever page they open in a book. 'Grazing' rather than 'reading' is the latest trend among the young, says children literary critic Dr Ronald A. Jobe of the University of British Columbia, Canada[14]. Besides, western writers' main emphasis while writing a popular science is to excite a young's interest in a subject rather than load him with facts, figures and concepts.

Sixthly, most Indian and some western books are very serious and stick to the subject under discussion. Only six books, namely, 'Folktales of Science', 'Light and Wrong', 'Roller Coaster Science', 'The Story of Illness and Getting Better', 'Alexander Graham Bell' and 'Mysterious Science' are written in a lighter vein, showing that scientists and science also offer a lot of scope for fun and humour. Except the first which is published in India, the rest are published in the West.

Lastly, the western books are multicoloured, full of real photographs and printed on glossy paper. Besides, the typography is large suiting the age group of the young readers they are addressing. In Indian books, photographs are a rarity. Most books are either black and white or in two colours, i.e., black and another colour. Paper used is often of an inferior quality.

Why Indian Books are Different ?

Now the next question that comes in is, why is this difference so much evident? There are several reasons, some are obvious and some not so obvious. Let us take them one by one.

Historical Background : Science writing is about two century old phenomenon in India, from the British times, from the early part of the 19th century, when some Indian magazines started publishing articles on science. It gathered momentum in the early part of the 20th century, when some Indian scientists like J.C.Bose, S.N.Bose, M.N.Saha and others made a mark in the world of science. But science writing for children was actually initiated in Bengali language somewhere in the 1940s by the great scientist S.N. Bose when he founded an organisation 'Bangiya Bigyan

Parishad' and a magazine devoted exclusively for popularising science among the young.

After Independence in 1947, when science was taken up in a big way in the country the efforts to popularise it in regional languages like Bengali, Marathi, Assamese, etc. continued. Programmed publication of popular science books began by setting up organisations. But organisations do not produce books. Books need writers who are committed to communicate science to the young. This trend has started in recent times only in English and some regional languages. More and more writers, Non-Governmental Organisations (NGO) and publishers have begun to realise the importance of popularising science among the young. Perhaps, this trend can be attributed to several factors, such as, growing awareness about science through various media, curriculum changes in the school, parents' emphasis on more scientific information for their children, purchase of popular science books in bulk by various Indian states, the efforts made by several NGOs to bring science to the masses, etc. NGOs like 'Eklavya' and 'Vigyan Prasar' and publishers of national repute like Children's Book Trust and National Book Trust are making noteworthy efforts in this direction. Writers like Arvind Gupta, R.K. Murthi, Dilip M. Salwi and so many others in some Indian regional languages are devoted to communicating science to the young. Of the 20 odd books, only a handful of the authors, namely, Arvind Gupta, Dilip M. Salwi and Yatish Aggarwal are qualified to write on science. R.K. Murthi, Monisha Bobb, Navkala Roy and Jagannath Mohanty write for the young.

Moreover, very few artists or photographers have yet to enter this field wholeheartedly. Artists or photographers need to have interest and inclination to do science illustrations. Often artists or photographers are the persons who had given up science early in their schooling careers. They are often afraid of science and want to keep off it. Unless a special effort is made to sensitise artists or photographers to science, it is difficult to expect well illustrated science books from India. It is not that the western countries do not have these problems but their history of science writing is very old — as old as science itself — and concerted efforts are in progress to sensitise artists and illustrators to science.

Education Pattern : In India, unlike in the western countries, educational system is quite rigorous, especially at school level. It is rigorous in the sense students have to read, learn and understand loads of textbooks on various subjects from a very early age. Necessarily, much emphasis is on rote-learning, less on experimentation, and still less on understanding concept in science. Popular science books are therefore written like school textbooks located with facts and figures. Experiments are not given much importance, though concepts are part of the text but they get lost in the verbiage. After all, the writers have also gone through the same mill !

On the other hand, books published in the West are written by persons who are interested in the subject — and are not necessarily experts in the subject — as well as are keen to share their knowledge with the young. If there is a need for an expert's advise, scientists in the field are consulted and all the facts, figures and concepts are checked and re-checked. Sometimes, scientists are also included in the book publishing team as consultants.

Publishing Industry : One cannot avoid the simple truth about publishing industry anywhere in the world that, it is commercial in its interest. If something sells, it will certainly be published. So is true about the publishing industry in India. In recent years, popular science has caught their attention for the simple reason that several Indian states have programmes of buying popular science books for schools in bulk. Today, an Indian publisher is keen to publish a popular science book if he feels it will be bought in bulk. Popular science books published to cater to the needs of individual buyers are still few and far between. The result is that books are published taking into account the author's authority, name and educational background only and not his ability to write the book for the young. Besides, the author himself has to give reference for illustrations for publication in the book, which the artist often copies for reproduction. Often, no additional effort is made by the publisher or its editorial and art department to improve the quality of the book, be it the text or visual appeal. As a result, the book is totally an author's brain-child.

In the West, the editorial and art department of the publisher has a big role to play in giving a final shape to the book. The book is treated like any other product of consumer interest. It is reviewed, rewritten, if necessary, by skilled writers, opinions about it is taken of experts, and artists, photographers and book designers are properly guided for the job. Of course, this means considerable additional money for the publication of the book. The western publisher does this expense because he knows a good product will sell very well. In India, such a possibility is rare and that is the reason why publishers take less care to publish quality books, or for that matter, quality popular science books for the young.

Lack of Communication Skills : Communication skills are given the least importance in the educational life of an Indian science student or scientist. He therefore may be a very good scientist, but lacks the skills to present science especially addressed at the young. Those Indians who have good communication skills lack scientific knowledge. Although this problem also exists in the West, it is more acute in India for two reasons: English is a foreign language and the book is the sole brain-child of the writer. In the West, the editors of the publishing houses offer considerable feedback and assistance for more effective presentation of the books.

Psyche of Scientists and Science Writers: Science is considered to be a serious subject by one and all in the profession, whether it is India or the West. Anything humorous or funny is scoffed at or looked down upon. In fact, it is discouraged by claiming that it trivialises the subject. That is why popular science books are mostly written in a serious vein. It is all fine if a textbook or academic book is treated in a serious manner but not a book meant to create interest in science among the young. The young people like humour and fun. And if science is blended with humour and fun, it will certainly appeal to the young.

Suggestions for Improvement of Indian Popular Science Books

Under Indian conditions, the quality of popular science books for the young depends much upon the publishing houses. Unless they make special efforts to produce quality science books, science writers and artists cannot do much. Be that as it may, the following suggestions come forth from the study for publication of quality popular science books in India.

Science books should not be considered as the sole brain-child of the author. The manuscript should be vetted by the concerned subject specialists, their suggestions not only on the subject matter but also visual presentation should be taken into consideration. If there is a need, scientists should be hired as 'consultants' to the book.

Artists, illustrators, layout artists, photographers, etc, should be consulted as soon as a manuscript is accepted for publication by a publishing house. They should be asked to give suggestions and new ideas of presenting the book to the young. In fact, a meeting of the author, artist and all concerned persons should be organised so that all ideas are sorted out for a more effective production of the book. Efforts should be made to organise workshops to sensitise them to various facets of science and its effect on society.

The author should be asked to submit a list for 'Further Reading' to the book so that any inquisitive young reader can further explore the subject, if he wants to.

An Index and a Glossary should be included at the end of every science book so that a young reader can look up any information easily and quickly while 'grazing' rather than reading the book. Besides, an Index helps him in tracking down a particular piece of information required in home work or at school.

More scientists should be involved in writing science for the young. Ideal would be a collaboration between one or more scientists in a field with a science writer and an illustrator who can present their ideas in a more effective manner. Workshops, etc, should be held from time to time to train scientists in the art of communication to the young and to inspire well known children's writers to write on a scientific subject. Ideal would be to train science graduates or even undergraduates in the art of communicating science to the young.

Feedback from the young readers on the books addressed to their age should be taken before the book is finalised for publication. Changes in the text as well as visual presentation should be brought in the book on the basis of the feedback.

Interactive books should be written as it encourages a young to look around, do something with his hands, and get a feeling of achievement. Such books will sustain the interest of the young in science in the long run. Indian books should therefore contain activities and experiments to support the passive text.

Scientific information should be weaved with history, biography, statistics, etc. to make it more interesting and palatable for the young.

Scientific information, concepts, ideas, theories, etc, should be communicated to the young in form of bits and pieces without going into too many technical details.

Lastly, but not the least, science should be made to look like a fun activity, containing humour, the thrill of adventure and exploration. The entertainment value of a popular science book should not be forgotten or ignored.

Before concluding a small anecdote from the life of the great scientist Albert Einstein which has much to say about writing popular science books in India as well as in the West.

"Once upon a time an eager and anxious mother approached Albert Einstein for advise. Her young son was a budding scientist, and she needed help in laying out an appropriate course for his studies. "What should I read to him?" the mother queried. Einstein nodded his cloud of white hair and replied, "Fairy tales." Startled, the mother came back with, "Fine, but then what?" Einstein peered at the woman over his spectacles and said, "More fairy tales." Exasperated, the mother persisted, "And after that?" Einstein leaned closer to the woman. "Still more fairy tales"[15].

Future of Popular Science Books

"This is the best time for science books for children since I've been in the business," says the Book Editor of Reuther, a publishing company[4]. On the other hand, DayAnn M. Kennedy, Stella S. Spangler and Mary Ann Vanderwerf say in *Science and Technology in Fact and Fiction*, "Every year an increasing number of librarians, teachers and parents report that young people of all ages are requesting more books about science and technology"[5]. These bright signs for popular science books for the young are not simply for the western countries. In India, too, demands for more popular science books are on the rise, thanks to various state-run science programmes and interest in science created among the young by television channels such as Discovery and National Geographic. The reader is looking for science books in the market. Now it is a question of providing him the best interactive science books which will create and sustain his interest in science.

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This writer is thankful to Ms Barbara Scharioth, Director, IYL for offering the prestigious IYL fellowship and therefore giving him an opportunity to visit the

IYL library, see and browse through its huge collection of children's books as well as of authoritative books written on children's literature. It has been an enlightening experience.

This fellowship has also helped in several ways. For the first time, this writer got opportunity to re-read his own books critically, read popular science books written by his fellow Indian writers and also the latest popular science books published in the West, which was not possible back home. It has given birth to several new ideas.

The writer is particularly thankful to Jochen Weber for some useful discussions, suggestions and assistance; to Christa Stegemann, Werner Kuffner, Lene Eubel-Plag, Parwin Abkai, Germana Schuff, Martha Baker and Petra Kuse for helping him not only in library matters but also in so many other ways.

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Science News

Indian Children Selected for Student Navigator Programme of Planetary Society, USA

ISRO had selected 12 Indian entries for 'Student Navigator Programme' of Planetary Society, USA. Of the 12 students, 7 were in senior, 3 in junior and two in sophomore category. The names of these students are :

Senior Category

1. Abhishek Vijay Thakur, Mumbai
2. Arjun Shankar, Bangalore
3. Avinash Sastry, Bangalore
4. Kautabh Rajeev Mote, Pune
5. Shaleen Rajendra Haralalka, Udaipur
6. Siddharth Chaturvedi, Bangalore
7. Srikanth Sridharan, Bangalore

Junior Category

1. Bhushan Prakash Mahadik, Mumbai
2. S.P. Kamalayazhini, Pondicherry
3. Sastry Lakshminarayan Vadlamani, Bangalore

Sophomore Category

1. Avinash Chandrashekar, Chennai
2. Harikrishna Ramani, Chennai

This worldwide competition for selecting 'Student Navigators' was conducted by the Planetary Society, USA and the LEGO Company, USA, and other sponsors, in cooperation with National Aeronautics and Space Administration (NASA), USA, the Jet Propulsion Laboratory and Malin Space Science Systems, USA. The 'Student Navigators' selected from India and many other countries will participate in a real exploratory mission of the planet 'Mars'.

The preliminary selection of the Indian entries was carried out through 16 designated regional centres: Science City at Chennai, Nehru Planetarium at New Delhi, Visvesvaraya Industrial and Technological Museum at Bangalore, Raman Science Centre at Nagpur, Inter University Centre for Astronomy and Astrophysics (IUCAA) at Pune, Nehru Science Centre at Mumbai, Birla Industrial and Technological Museum at Kolkatta, Kerala Academy of Sciences at Thriuvananthapuram, Panorama and Science Centre at Kurukshetra, Vikram Sarabhai Community Science Centre at Ahmedabad, and Regional Science Centres at Bhopal, Calicut, Lucknow, Bhubaneshwar and Guwahati.

Of the above twelve students, the NASA has finally selected three students from India to participate in its "Mars Surveyor 2003" project. The results about the selection were declared in the first week of March 2001. The three students would be amongst the seven member international team of youngsters constituted through a global competition to serve as student navigators for the Mars mission. The three Indians in this international team include the thirteen-year-old Bhusan Prakash Mahadik, a ninth class student from Vapi, Mumbai, accompanied by seven year old Avinash Chandrasekhar from Chennai and Shaleen Rajendra Haralalka from Udaipur. Another two Indian youngsters Harikrishan Ramani and Kamalayazhini, S.P. have been selected to be in the four member back-up team for the project.

These students will get an opportunity to live in a stimulated Mars base at the Jet Propulsion Laboratory while they will be participating in the tele-operation of a Martian vehicle known as Marie Curie Rover and its Robotic arm, which will be operating on the surface of the Mars. Their training is to begin immediately after selection through internet followed by a two week hand on training in the month of October 2001.

Scientists Reduce Speed of Light to Zero

Researchers have been able to reduce the speed of light from 3 × 10 kms to zero, trapping light beams for short periods of time before allowing them to burst forth again at full speed. It is as if physicists can manage to capture light, play with it for a while and then let it go.

The discovery does not break any laws of physics, but it does illustrate the bewildering intricacies of quantum physics that often seem to defy logic.

Two teams of researchers working independently have announced the discovery. The physicist Lene Vestergaard led one of the teams, Hau, Harvard University, USA while the other team has been jointly led by Mikhail D. Lukin and Ronald Walsworth from Harvard — Smithsonian Centre of Astrophysics in Cambridge. The discovery represents a major step toward the development of so-called quantum computers which would manipulate the intrinsic physical characteristics of atoms to be orders of magnitude more powerful than today's supercomputers.

According to physicist, Aephraim Steinberg of the University of Toronto, the discovery would enable scientists to store information carried by light for much longer periods of time than was thought possible in the past.

The speed of light is a constant in vacuum, but it slows down as it passes through glass, water and a variety of other materials. If it were not so the refraction of light could not be possible. As a result we would not have magnifying lenses, rainbows and a host of other phenomena. But glass or water slows the speed of light only by about a third, and physicists have been trying to retard it much more radically.

It may be mentioned that in an experiment conducted about two years ago, the Hau team shined a pulse of laser light through a cloud of super cold sodium ions and slowed the light to about 60 kilometers per hour. In effect, the sodium cloud acted like thick molasses that grabbed photons of light and slowed their passage by a factor of more than 10 million.

However, the research teams independently have now been able to bring a light pulse to a complete stop before allowing it to burst forth once again.

In the recent experiments, a 0.8 km long pulse of light is made to enter a chamber that is only a fraction of centimeter wide and is slowed so drastically that all of the beam enters the thin chamber before any light begins to come out of it.

Both groups used clouds of metal atoms cooled to few-millionths of a degree above absolute zero. Lukin's group used rubidium and Hau's used sodium.

Normally such clouds would absorb any light beam shined on them and in the process destroy any information contained in that light. But using a precisely tuned laser called a coupling beam, researchers can alter the quantum states of the metal atoms to allow them to re-emit the light, a phenomenon known as electro magnetically induced transparency.

In fact when the light passes through the cloud, it interacts with the spin state of the atoms, a phenomenon that slows its passage. The spin state of an atom is like a tiny bar magnet with a specific orientation in space. Changing that spin state is akin to pointing the magnet in a different direction.

In the new experiments, the researchers shut off the coupling beam while all of the light pulse was in the chamber. They could halt the beam for as long as a millisecond before turning the coupling beam back on and allowing the light pulse to re-emerge at full speed.

A millisecond may not seem like much, Steinberg said, but light moving at its normal speed would travel 300 kilometres in that period.

What actually happens to the photons of light during this period ? In essence, they disappear, with the information they contained being stored in the spin states of the metal atoms. When the coupling beam is turned back into a light beam identical to the original in all its characteristics and information content, but somewhat weaker.

The researhers believe that the little change, in the process of absorption of photon i.e. in the spin stage instead of heating the atom, could work like just the switches in computers. Since, there is no loss of information, one could store zeros and ones just like they are stored in computers. But it would happen much faster and, using the sometime weird laws of quantum mechanics, one photon could have more than one "on-off" position at the same time. This property could be used to make ultra fast quantum computers.

Greenhouse Water from the Sea

A Green House that used sunlight to turn salt water into fresh water for growing vegetables or drinking purposes has been developed. Operating at lower cost than traditional desalination plants, the greenhouse designed by English architect Charlie Paton is undergoing trials with European Community funding in Tenerife and Oman.

Constructed close to the sea, the steel-framed greenhouse measures 5.5 metres × 18 metres × 48 metres. It can be made larger by linking further modules together.

Made of bended tubular metal embedded in concrete, it is covered with a double-skinned roof that prevents infrared and ultra-violet light from over-heating the structure.

The red and blue light spectrums that penetrate into the greenhouse drive the plants' photosynthesis process. With evaporators at each end made from corrugated cardboard, the greenhouse has large surfaces from which seawater can evaporate leaving its salts behind.

These strengthen the cardboard giving it a much longer life. Warm air is drawn into the greenhouse and passed through one of two evaporators, which are cooled, by seawater. Drawn by fans, the humid air saturated with moisture creates ideal conditions to grow greenhouse crops.

After passing through the growing area the air arrives at the second evaporator, which is also cooled, by seawater. The fresh water in the air condenses and is collected for irrigating the crops or stored in a tank and used for drinking purposes.

The prototype had been tested in a number of countries but as climatic conditions demanded different requirements, the greenhouse technology will be made available on license basis to the users.

(*Source* : Spectrum)

Cancer in Mice Prevented by Gene Therapy

The members of the team of microbiologists and immunologists working at the Jefferson Medical College in Philadelphia, USA were surprised when an experiment conducted by them have shown that gene therapy can lead to prevention of certain types of cancer in mice. While the researchers still do not believe that gene therapy can cure cancer, yet they are convinced that their experiments may help the search for new and better targets for cancer drugs and may offer ways to prevent cancer from ever developing in the first place invulnerable people, such as smokers. In this experiment, gene therapy has not only been used for the first time ever to prevent cancer in mice but was also given orally, something that is even more astonishing as until now the scientists had never been able to do so. Although it was known that cancer cells could be killed in the laboratory but the researchers were not sure if the stomach juices would allow them to act on the viruses. Some differences were expected, but the observations have been far more dramatic.

In the experiment, the researchers targeted a gene called FHIT, which is damaged in many forms of cancer, from breast to colon cancer. FHIT causes damaged cells to commit suicide before they can start the out-of-control growth of cancer. Cells in which this gene is damaged by carcinogens, such as the toxins in cigarette smoke, do not die the way they normally would. For their experiment, the research team used mice bred to lack the gene. According to Dr Carlo Croce of Jefferson Medical College, the leader of the study team, the fore stomach of the mouse corresponds to the lower part of the esophagus in humans. When mice are genetically engineered to lack a working copy of the FHIT gene, they are vulnerable to a condition that resembles

Barrett's esophagus, an irritation of the esophagus that can lead to oesophageal cancer in human. According to Dr Croce the frequency of this type of cancer is getting higher and higher, particularly in the United States. Their experiments have shown that cells affected by Barrett's are missing FHIT. So they bred mice to lack one copy of the gene and then dosed them with a chemical known to cause oesophageal cancer called nitroso-methylbenzylamine (NMBA).

The researchers then tested to see if giving the FHIT gene to the mice would protect them. The basic idea behind gene therapy to is replace a faulty gene to treat disease, but cancer had been thought to be too complicated, involving too many different genes, to be easily tackled in this way. Croce's team divided their genetically engineered mice into four groups — one given NMBA alone, one given NMBA and then treated with an adenovirus, related to cold viruses, that carried the FHIT gene. The third group got a different kind of virus, called an adeno-associated virus, with the FHIT gene. The fourth group of mice got both viruses as vectors. Some scientists think adeno-associated viruses, which do not cause disease in humans, are safer and more effective vectors or carriers for gene therapy. Dr Croce described the results of the study to be stunning because of the fact that treatment with virus — in particular, adeno – associated virus carrying FHIT – prevented the mice from developing cancer, which according to him indicates that we can prevent cancer with gene therapy.

However, Dr Croce said he did not believe that cancer could be cured this way and it would be impossible to infect and then kill 100 per cent of the cancer cells. But if one can kill 90 or 95 or 99 per cent of pre-cancerous cells then the cancer will not develop. Dr Croce predicted that the first disease that may be prevented in future would be Barrett's esophagus. The next will be bronchial dysplasia. Most heavy smokers have bronchial dysplasia, which will later lead to lung cancer. His findings may affect treatments for a range of cancers, such as lung cancer, colon cancer, and some types of breast cancer and bladder cancer, which also involve a damaged FHIT gene. Still Dr Croce does not believe that the gene therapy will be the answer to the treatment of cancer. But we not know that FHIT could be used as a target. Dr Croce said that the FHIT gene is huge and is vulnerable to damage, and seems to work along a "pathway' with other genes. It might be possible to develop drugs that affect the other genes in the FHIT pathway.

Astronomers find Monster Embryonic Star

Astronomers studying radio waves in space say they have found a monster embryonic star in the constellation Orion that might have the potential to form planets.

Scientists have identified dozens of possible planets outside our solar system, but all are believed to be orbiting stars about the mass of the Su. This is the first time astronomers have spotted a so-called proto-star that has about 10 times the Sun's mass.

The sign that planets might be possible around the proto-star—known to scientists as G192. 16-3-82 and located some 6,000 light years from Earth — is the presence of a disk of dust and gas circling it. A light year is the distance light travels in a year.

This feature, called an accretion disk, has about the same diameter as our solar system, according to scientists at the National Radio Astronomy Observatory (NRAO) in New Mexico. In the case of stars like our Sun, planets coalesce from material in the disk.

Rice Genome Decoded

A Swiss agrichemical Company Syngenta had announced that it had mapped the DNA code of rice. It is expected that the DNA mapping would accelerate the development of enhanced versions of the crop. In the culmination of a three-year project, the research group had succeeded in sequencing 99.5 per cent of the rice genome — the first major commercially important food crop to have its DNA unravelled in this way.

The "brakthrough" accomplishment would enable plant breeders to develop hardier, higher yielding strains of rice within four to five years.

According to Peter Meldrum, president and CEO of Myriad genetic Inc., who collaborated with the project, this is tremendous scientific accomplishment that I believe will rank as one of the top scientific breakthroughs of the genomic era. The development of higher-yielding crop varieties may put us on the road towards the elimination of world hunger.

Rice is a staple for half the world's population, but is vulnerable to drought, disease and certain insects. The hope is that the genetic blueprint developed by Syngenta will allow plant breeders to manipulate rice DNA to produce more disease-resistant strains that are also able to withstand drought and heat.

Researchers believe that the study provides foundation for functional studies and would facilitate in identifying not only the genes, but their functions and how they work. It will provide researchers with crucial new knowledge to improve food crops.

The blueprint will be made available immediately to the scientific academic community, including the International Rice Genome Sequencing Project — the public sector mapping project by the government of Japan.

That project is not expected to complete its blueprint until 2003, but is working to a more exacting standard.

Robots to make Human Life safer

A new breed of small, animal-life robots to do all the dull, dirty and downright dangerous jobs that will be increasingly found in technologies of the 21st Century is already being designed and built in the United Kingdom.

The robots could soon be used to create willing colonies of miniature workers helping to clear up landmines, welding the inside of ships' hulls, working in nuclear reactors or even being involved in dangerous search-and-rescue missions.

This novel design project at the University of the West of England at Bristol is essentially focused on creating groups of simple robots that can collectively achieve a more complicated task: emulating behaviour epitomised by the industry and efficiency of a typical and colony. So far, the experiments have been based on research carried out on the behaviour of Leptothorax ants by the project leader Dr Chris Melhuish, who is the Projects Director of the Intelligent Autonomous Systems (Engineering) Laboratory.

Dr Melhuish found himself faced with the task of getting a dumb robot to perform smart operations. He found the answer he was looking for in the study of social insects where relatively unintelligent creatures could collectively combine their limited talents to perform incredible tasks.

"Task termites who are able to build amazing 'clay cathedrals' that are not only impressive in their sheer size but in their intricacy", he said. Although no single termite in a colony has a blueprint for constructing an intricate nest, they go on and build it anyway. In the same way Dr Melhuish's robots are already able to successfully cluster and sort coloured discs in a robot arena without individually having a clue about what they are doing.

Studying what insects have achieved through centuries of evolution has led him to a personal definition of intelligence. He says that it is possible to get things right for some of the time, which means intelligence can be achieved without having consciousness or self-awareness.

Working along similar lines is the Portech Company, Southern England that has also been looking at the natural world for inspiration to create a spider robot that can explore difficult terrain. Dr Stuart Galt was originally motivated by a US Army survey, which showed that 50 per cent of our planet's surface couldn't be negotiated by wheel technology. He realised that what was needed was a new type of vehicle that did not rely on wheels.

To seek a possible answer he studied insects such as cockroaches, crabs and spiders. From this he realised that very long legs coupled with a small body made the vehicle easier to control.

Used Tyres to Reduce Traffic Noise

LD plastic bumpers and tyres from scrapped cars are being used in a noise-control project launched by researchers in the United Kingdom, in collaboration with partners in the Czech Republic and Japan.

The polymer bumpers are shredded into a small gritty substance that is bonded into a matrix of porous material and used to deaden traffic noise, to soundproof buildings and improve acoustic control.

The tyres are granulated and combined with polyurethane for a variety of uses such as noise reduction in vehicles and road barriers.

According to Dr Kirill Horoshenkov of the Department of Civil and Environmental Engineering at Bradford University, northern England, this is a win-win-win scenario.

Polymers used specifically for the purpose would be very expensive whereas many scrap polymers had a negative cost because of the taxes and transportation costs to be borne for their disposal. In addition, the technique could also be helping to get rid of plastic that is so difficult to dispose of in other ways. Recycled in an environmentally friendly fashion it can reduce noise pollution and help to improve the qualify of life.

The problem of vehicle-generated noise in particular has risen with the number of cars and trucks on UK roads. Planning guidelines limits noise levels to which households are entitled to insulation grants but in the majority of cases, Dr Horoshenkov believe, it is cheaper to construct a single effective barrier, one side of which is covered with an acoustically absorbing material.

There are many existing sound-absorbing products ranging from porous concrete walls to wooden fences filled with fibreglass. "If you are going to use large amounts of sound-absorbing materials in barriers or on building, cost is the key factor. This recycled polymer and the granulated tyres could be viable and durable for such purposes," said Dr Horoshenkov.

The Bradford research team is optimising the acoustic and thermal properties of their recycled polymer. They are also testing other important, physical, mechanical and chemical properties of the substance in an attempt to develop an inexpensive process for industrial mass production.

Dr Horoshenkov is collaborating with scientists at the Technical University in Brno in the Czech Republic and the Kyshu Institute of Design in Japan which specialise in the manufacture of acoustic materials. The new product is expected to be marketed in 2001.

(*Source* : Spectrum)

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Another Argument Against the Use of Calculators in School Mathematics — *Examined and Found Wanting*

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In my book "Calculators and Computers in Mathematics Education : Myths and Realities" (MSTS), I examined ten arguments against the use of calculators in schools mathematics and showed that all these arguments were based on fallacious reasoning and none was validated by any objective scientific experiment. In fact most of these arguments were given by persons who had either not used calculators or had used them for carrying out only the four basic operations of addition, subtraction, multiplication and division, but had not used scientific calculators for any mathematical work beyond these operations.

However I recently got another argument which was made by a mathematician and therefore deserves an important consideration. The argument was as follows :

"I am a Ph.D degree holder in mathematics and I am teaching and guiding research in mathematics. I have never used a calculator or a computer and I never felt the need for them. All the problems in school mathematics textbooks and even in undergraduate mathematics textbooks can be done without using any calculators. Why then do you think that students should be given calculators ?"

I had heard a similar argument at IIT Kanpur from a superintending engineer whose son had been admitted to that institute "I have not used mathematics or science or humanities or even 90% of the engineering I was taught. I use some rules of the thumb and approve tenders and supervise the works according to the conditions in the tender. Why are you teaching the students so many courses in mathematics, physics, chemistry, humanities and engineering ?"

I told him at that time, "That is precisely the reason why we have not done so well in engineering and that is why these IIT's have been started, so that the engineers produced here may work on frontiers of knowledge and may design new structures or new power systems needed by the modern age."

Argument Examined

(i) I agree that all the problems in school mathematics textbooks as well as in most under-graduate textbooks can be done without using calculators and computers and students can get 100% marks in the examinations based on these textbooks without using any calculators. *However this is so because all the problems have been specially designed to be solved without the use of* *calculators and by avoiding all real-life problems which require the use of calculators and computers.* I can write textbooks in which every topic will have real-life problems requiring the use of calculators and the persons who do not use calculators will not be able to even pass examinations based on those textbooks and these books will be written for the present curriculum only. All the problems I give in the new textbooks will be real-life problems dealing with daily life as well as real problems in science and engineering.

If the object of teaching mathematics is to enable students to pass examinations and the object is not to use mathematics in daily life or in science, then the present sets of problems may be all right, but if we want mathematics education to be relevant to life then problems have also to be relevant to life and these problems cannot be done without the use of calculators.

(ii) The present sets of problems were mostly designed when calculators and computers were not available. If you look at the problems in textbooks today, they are almost the same as problems given in pre-1950 textbooks. Of course some topics have been brought down from higher levels to lower levels, but problems in those topics have also been brought down intact, without taking into account that mathematics and science have undergone revolutionary changes in the past 50 years due to the availability of calculators, computers and information technology and due to newer applications of mathematics.

(iii) Earlier mathematics problems were all *artificial* problems to illustrate the theory and to give practice in solving problems. The problems are still artificial, even though they are sometimes so phrased as to appear to be practical problems, but since they avoid calculations, they still remain artificial or applicable to pseudo-applications. As soon as you try to make these problems real-life problems, they require the use of at least scientific calculators. Some of them may even require the use of graphic calculators and computers and our insistence on not placing their computing powers in the hands of our students has completely prevented us from giving them real-life problems. It will not be difficult to add problems on each topic which are real problems and require significant use of calculators. The solutions of these real problems with the help of calculators will not take more time than the solution of the present day artificial problems without the use of calculators.

(iv) At present for most problems, the solutions given are only half solutions, because they do not give students insight into the solutions. Thus saying that the number of ways in which we can make groups of 20 out of a set of 50 objects is $50c_{20}$ is not a solution. It is only a way of rewriting the original problem. It is not even enough to say that the number of ways is $50!/(20!30!)$ because it does not tell us whether the number of ways is in thousands or millions or billions. If we have a scientific calculator we can easily see that the number of ways is given by —

$$\frac{50!}{30!20!} = \frac{3.0414093 \times 10^{64}}{(2.432902008 \times 10^{38})\,(2.632328378 \times 10^{11})} \cong 10^{14}$$

This gives us some insight and can be called a solution.

Many of the answers given in text-books of mathematics are in terms of symbols and thus are pseudo answers. (vi) Problems in arithmetic textbooks have simple exact answers, while in most real-life problems, the answers can only be obtained approximately, of course to any degree of accuracy one likes. This itself shows that the problem given in the books are artificially constructed, so that they have very simple easily calculable solutions.

Some Real Life Problems Requiring the Use of Scientific Calculators

(i) A finance company pays interest at the rate of 8.75% compounded monthly. What will be the maturity of value of Rs.100 at the end of 3 years or 5 years ?

The answer is

$$\left[100\left(1 + \frac{8.75}{1200}\right)^{36} \text{ or } 100\left(1 + \frac{8.75}{1200}\right)^{60}\right]$$

The first requires us to calculate $(967/960)^{36}$ and the second requires us to calculate $(967/960)^{60}$. Manually it is almost impossible to calculate these values without making mistakes.

An alternative way is to calculate antilog *[36(log967-log960)]*. We can consult the log tables, find out the characteristic and mantissa for ln 967 and ln 960, subtract and multiply by 36 or 60 and then take antilogs of the expressions obtained. Log tables are given to four places or seven places of decimals and we have to use linear interpolation in tables of log function which is not linear function. We may get the answers after 5 minutes and these will be very crude answers.

The third way is to take a scientific calculator, press the button for 967, then for division, then for 960, then press the button for x^y and then press the button for 36 or 60 and we get the answer in 5 seconds and this is more accurate than the answer given by log tables.

Even otherwise all the log tables are given to 8 or 9 places in a small hand-held calculator and it appears meaningless to use bulky log tables in place of the small hand-held calculator.

When the same information is available in such a small size no body in banks and no individual uses log tables for this work. The use of log tables gives no more insight than the use of scientific calculators. Log tables and even tables of trigonometrical function should now be played in measures.

Thus the only alternative to solve the real-life problems which occurs in daily life is to use the scientific calculator, because the other alternative of manual calculations may take an hour or more and then we shall not be sure that we have not made some error and we will have to check and recheck a number of times. With the use of calculators even checking and rechecking will take only a few seconds.

It is tragic that even our mathematics graduates will have to accept on faith the calculations made by the bank clerks with the help of calculators and they will not be able to check the results themselves for such a simple problem.

There is also a fourth way which is used by our curriculum designers and textbooks authors, by prescribing that the interest will always be compounded annually and will be at the rate of 10%, so that the calculations are simple. Fortunately or unfortunately these curriculum designers have no control on the banks, otherwise they could have a simpler method of dictating that only simple interest should be paid or even that no interest should be paid, so that the students and teachers will have no inconvenient problems to solve!

Another convenient way will be to throw out compound interest from textbooks, but they cannot be thrown out of life!

(ii) Again consider real-life problems arising from buying products on instalment basis. Suppose a person buys a car worth 5 lacs of rupees. He pays one lac rupees in cash and agrees to pay the rest in 24 equal instalments, starting from next month. The rate of interest is r% per annum and we have to find the required instalments. If P in lacs is the instalment then we get the equation $1(1+r/1200)^{25} + P(1+r/1200)^{24} + \dots + 1(1+r/1200^{1} + 1) = 5(1+r/1200)^{25}$ or

$$P = \frac{r}{3001}\,\frac{1}{+ r/1200-(1+r/1200^{-25})}\text{ lacs.}$$

Knowing now we should be able to calculate the instalments in a few seconds, if we have a calculator and may be in a day if we do not have the calculator. Further, knowing the instalment we can form here an equation of the 25th degree in n to find out the rate of interest which is being charged.

However students are taught to solve only second degree equations and equations of higher degree are out of their course. They are not taught solutions of higher degree equations sometimes in higher classes also and a Ph.D in mathematics may not be in a position to solve this 25th degree equation unless he has done a course on numerical analysis with the help of calculators and computers, so that in the absence of availability of calculators and computers this simple problem is out of reach of mathematics students. This simple problem of purchase on instalment basis is out of bounds for mathematics graduates. What better comment can there be on the wisdom of those who deny the use of calculators to our students ?

(iii) In my book on *Suggested Experiments for a Mathematics Laboratory* I have given methods which will enable a high school student to solve this 25th degree equation in a matter of few minutes with the help of a calculator:

(iv) Knowing that the population of India increases by 2% per annum, we want to find out what will be the population in future years. The answer is that it will be $100(1.02)^n$ in the year 200n, if the present population is 100 crores. If we have a calculator, we can find the population of India, if it continuous to grow at the present rate, in the next 100 years in a time of a few minutes only. We can also find out what will be the population if the rate of increase of population falls down by 0.1% every year. These are real life problems for which the answers can be easily obtained with the help of calculators.

(v) Again suppose we want to find the rate of growth of population so that it doubles in only 100 years. We get $1+(1+r/100)^{100} = 2$ and we can calculate r by taking the 100th root of 2, but we tell our students only how to find the square roots. We do not even tell them how to find cube roots though the method for this was known in India more than 800 years back. With the help of calculators, it is as easy to find the 100th root as it is to find the square root.

(vi) One of the most important applications of mathematics is in finding maximum or minimum values of function $f(x)$ in an interval $[a, b]$. We tell the students to put $f'(x)=0$, solve it and for each solution to find whether $f'(x)$ is positive or negative. But we construct and give in our textbooks only those problems in which $f'(x)$ is a quadratic expression in sin x or x and as such do not know the student when $f(x) = 0$ has either an algebraic equation of third or higher degrees in what to x or it involves trigonometric, hyperbolic or exponential functions. He is completely handicapped in solving simple problems of maxima and minima except the artificial ones and in the absence of calculators, he is almost a mathematically illiterate person.

(vii) We do a large number of problems in arithmetic where the law of variation is the linear law, so much so that student even begin to believe that the linear law is perhaps the only law of variation in nature or in life. I have seen scientists performing experiments on a small scale in a laboratory and then extending the results to a larger scale plants in industry by simply multiplying the results by a certain scale factor. This will be valid only if the linear law holds. If the linear law holds then and to practical problem has a machine of 100 times the size of the laboratory machine, then multiplication by 100 will be justified, but if the quadratic law holds then he will have to multiply by 100^2 or 10000 and 10000 cannot be considered as a close approximation to 100!. We lay so much emphasis on linear law because it makes calculations simple and the calculations can be done manually. We do not teach the students that the variation may depend upon 2nd or 3rd or one and a half power of the variable, because this will make the calculations complicated. However we cannot order Nature to follow the linear law. Nature can help us in designing instruments like calculators which will take into account other possible laws without making the calculations more complicated. If we do not agree to use these newer calculating devices to solve real life problems, we shall be harming ourselves.

(viii) Our students prove a number of theorems in geometry, but they stop at the point where they are in a position to apply this knowledge of geometry to study tessellations—Aesher's art, painting, architecture, science and nature. They can find areas and volumes of regular figures, but are regular figures abundant in Nature? They cannot find even the areas of irregular fields or coding of irregular solid bodies. They cannot find the centre of gravity, centre of pressure and moments of inertia and this is at a time when mathematics can enable us to deal with fuzzy shapes and even shapes of clouds and coastlines, when we can find different periods of growth in situation, but our students are allowed to study very simple figures because the calculations for other figures become very messy if they are done manually.

(ix) In coordinate geometry, our students find very important locii, but their equations are always expressed in terms of abstract algebraic symbols. Our students cannot draw the graphs of these locii. They cannot visualise these locii, they can only see them in terms of abstract symbols which give them no insight into the nature of the locii. We have imposed a ban on ourselves not to do useful mathematics, because useful mathematics will require us to use calculators.

(x) Our students can find lengths, areas, volumes of regular bodies easily by using integral calculus. They cannot however find or they are not allowed to find these areas and volumes in concrete terms or in terms of numbers. Their capacity to see mathematics, to feel mathematics, to observe mathematical ideas becomes seriously limited because they cannot visualise the objects they are dealing with. What they do is only exercises in integration, though they are made to believe that they are finding areas and volumes.

(xi) Our students can solve two linear equations in two unknowns and with some difficulty, they may be able to solve three equations in three unknowns, but is almost impossible for them to solve for 10 equations in 10 unknowns manually. However in practice, we have to solve even a thousand equations in 1000 unknowns. For this purpose we may require computers but even with the help of calculators and some knowledge of matrices, we can solve up to ten equations in ten unknowns easily.

(xii) If a MATHEMATICAL or MAPLE V or mathematics laboratory programme is available on a computer even high school students can multiply 20 digit numbers, can solve differential equations and matrices and can do other large scale problems in a matter of seconds or minutes.

(xiii) If our present day teachers and students in India are not using scientific calculators, we cannot be proud of the situation. Sometimes we take pride in the fact that some of our bright students can do arithmetical calculations much faster than students of other countries. This may or may not be true because it has not been tested scientifically, but even if it is true it is at the cost of real understanding of mathematics and mathematical operations. Our students very often do not know what operations to perform but if somebody tells them the operations they can do the operations quickly. The real essence of mathematics is in mathematical thinking and mathematical modelling of real situations. It is certainly not in computations.

(xiv) We have given above some examples of situations in which use of calculators is indispensable. These examples can be multiplied *ad infinitum* and we can have textbooks full of problems requiring the use of calculators. These problems will be real-life problems and will not require more time. At the same time our students can use scientific calculators or graphic calculators and really understand what they are doing. Our denying these computational aids to our students is equivalent to a criminal act of permanently crippling our future generations from applying mathematics for solving national problems.

The statement that many of our students do not use mathematics in later life is true only because to use mathematics in present day life they require at least scientific calculators and if students are trained to use scientific calculators to solve real life mathematical problems, we shall find that the number of persons who make such statements will be drastically reduced in a few years.

Structure of Matter — Atoms, Nuclei and Particles

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One has learnt that all material objects basically consist of atoms. Within an atom, the structure involves a very tiny but very massive nucleus around which revolve the electrons. The positive charge on the nucleus equals the total negative charge carried by the revolving electrons, making an atom appear neutral from the outside. Textbooks show pictures of such an atom. Have you ever wondered whether these pictures are realistic enough ? Are these drawn according to some scale indicating the relative sizes of the nucleus, the electron and the atom! The answer is "no". If we take the nucleus to be of radius 1mm, the corresponding size of the atom comes around 10 metres. Electrons are to be taken as point particles having negligible mass relative to the nucleus. Thus, an atom becomes mostly an empty object within, since the nucleus occupies just one part of its volume compared with 10^{12} parts of the total atomic volume. It is not therefore a fascinating situation in nature that we still see solid objects in our physical world appearing as tight and compact? On the "microscopic" atomic scale, there exists a vast volume of emptiness within an atom. Such a mysterious aspect gets presented before us when we attempt to picture the atomic structure in a classical way based on the familiar experience of the outside "macroscopic" world.

Subatomic World

Continuing our journey in the fashion outlined above, we shall notice some more surprises about the sub-atomic world. We have learnt that the nucleus consists of protons and neutrons, the former having a positive charge that is equivalent to that of an electron (having negative charge) while neutrons are considered neutral. You will be surprised to note that the physics of the atom and the nucleus will remain unaffected if we had assumed the charge on the electron to be positive from the very beginning, as that would have compelled us to assume an equivalent negative charge on the proton. The force that binds protons and neutrons together inside the nucleus has to be strongly attractive and charge independently. Otherwise the nucleus could not have existed as an entity of extremely small size, having almost the entire mass of the atom, within a relatively much larger atom. You have learnt that this aspect was demonstrated by Rutherford and Geiger in their famous experiment showing large angle scattering of alpha particles by the atomic nuclei present in a thin gold foil.

When experiments were conducted with nuclear particles of much higher energy (~1000 MeV) bombarding the atomic nuclei, it was revealed that both neutrons and protons possess more or less identical positively charged core with surrounding clouds of negative and positive charges respectively. More realistically, such a surrounding cloud may be understood as due to mesonic (mass in between that of electron and proton) particle having either positive or negative charge. It is these which are exchanged continually amongst the neutrons and protons of the nucleus, keeping them bound together within the nucleus. Thus, any particular proton may change into a neutron and vice-versa. Such a process repeats at a very fast rate ($\leq 10^{-23}$s) and in any nuclear process (decay or reaction) that may be studied experimentally, a given nucleus always appears to consist of its assigned number of neutrons and protons. An experiment always involves time averaging of much larger duration than 10^{-23}s and hence one can not observe such fast interchanges of neutrons to protons and vice-versa.

World of Quarks and Gluons

In the preceding presentation, we had a glimpse of the sub-structure of neutron and proton as having a positive charge core with surrounding cloud of negative and positive charges respectively. In fact, experiment conducted by particle physicists using extremely energetic (over billion eV) sub-atomic particle beams necessitated the postulation of fractional electronic charge particles called quarks. These may, as of now, be considered as ultimate fundamental particles which constitute the various sub-atomic particles that have been discovered so far, besides the neutrons and protons. Strangely, fractional electronic charge equivalent of 2/3 or 1/3 the electronic charge, both positive and negative had to be assigned to the quarks. To illustrate, a proton is considered to have three quarks having charges 2/3 e^+, 2/3e^+ and 1/3e^-, while a neutron has quarks with charges 2/3e^+, 1/3e^- and 1/3e^-. Similarly, hyperons (mass greater than protons) and mesons (mass in between that of electron and proton) that have been discovered in particle physics experiments have been understood as consisting of appropriate combination of quarks.

Thus far, one has not succeeded experimentally to cause the breakup of a proton/neutron into its quark constituents. However, indirect evidence about the existence of quarks have been obtained in particle-particle interactions at extremely high energy (several billions eV). Search is however on to look for quarks astrophysically as it is anticipated that at the time of creation of the Universe, these should have existed as such, prior to the cooling of the big-bang environment which finally led to the formation of neutrons and protons and ultimately the various nuclei, atoms and molecules. Such appears to be the nature and sequence of creation in our Universe to the present day.

Concluding Remarks

Field theory in Physics is based on the postulate that there should exist a field particle that is exchanged between any two bodies that interact physically. In electromagnetic interaction it is the photon. In gravitational interaction, it is the graviton, which is still being looked for. In nuclear interaction, it is the exchange of meson between the nucleons (neutrons and protons) that keeps them bound within the nucleus. In a similar way, the quarks are supposed to exchange the particles called "gluons" on an extremely short time scale. Thus, the break up of protons/neutrons into quarks require extremely high energies in a laboratory experiment in order to observe the free quarks.

In fact, the universe at the time of creation may have been just a sea of quarks and gluons as the original particles of the physical world.. It is expected that some of the initial quarks may have escaped the process of formation of nucleons (protons and neutrons) and then the nuclei, the atoms and the molecules which constitute the matter today! Some stray quarks may still be moving around in some far corner of the world as free particles which can be looked for in astrophysical experiment.

Footnotes

1. Current instrumental capabilities are able to sense time intervals down to 10^{-14} s directly. However, indirect manifestations of time intervals down to 10^{-18}s can be sensed in physical processes, during an experiment.
2. It may be noted that the laws of conservation of energy conform to a time-averaged measurement. In fact, there can not be an instantaneous measurement. This limit is set as per the Heisenberg Uncertainty Principle, $\Delta E . \Delta t \cong h$ (Planck's constant). Any time uncertainty therefore leads to the corresponding energy uncertainty. Thus, it is perfectly possible that laws of conservation may not hold during ultra-short time based processes, which also are not possible to study experimentally in a dynamic sense.
3. $1 \text{ eV} = 1.6 \times 10^{-19}$ Joule (macroscopic energy unit).

Performance of Students in Science and Mathematics at the Secondary Stage (1998-2000)

An Analysis

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Analysis of the performance of students in Science and Mathematics at the secondary stage of the Central Board of Secondary Education, New Delhi, from 1998-2000, was undertaken by the Department of Education in Science and Mathematics of the National Council of Educational Research and Training. The relevant statistical data were provided by the Central Board of Secondary Education.

The objective of this analysis was to find out whether poor performance of students, specially from the Government and Government-aided schools and those appearing from the Patrachar Vidyalaya (PV) and as Private (PVT) Candidates, in the subjects Science and Mathematics, as is the general belief, was responsible for the dismally low pass percentage at the secondary examination conducted by the Central Board of Secondary Education.

Some of the significant features of the performance of students, both boys and girls, in Science with Practical and Mathematics examinations from different categories of schools including Government-aided, Government, Independent, Jawahar Navodaya Vidyalayas, Kendriya Vidyalaya Sangathan, PV and PVT candidates, from all over the country, and the inferences drawn for the years 2000, 1999 and 1998, are as follows.

Science

Year 2000

Out of 438032 students that appeared in the Science with Practical examination, only 401114 (91.57%) students passed in the examination. The remaining either failed (7.15%) or were placed in compartment (1.07%). The result of 0.21% students was withheld.

The pass percentage of girls (92.90%) was higher than that of boys (90.60%). However, the percentage of girls (1.25%) placed at the compartment was higher than that for the boys (0.94%). The mean mark for the girls (55.8) was slightly higher than that for the boys (55.5).

The percentage of students that scored marks in the range of 33-39% was 20.25% (girls — 21.90%, boys — 19.04%) whereas the percentage of students that scored 75% marks and above was 23.08 (girls - 23.50%, boys — 22.78%). The percentage (5.67%) of failures among girls was less than the percentage (8.22%) of failures among boys.

Among the various categories of schools such as Government-aided, Government, Independent (public), Jawahar Navodaya Vidyalayas (JNV), Kendriya Vidyalaya Sangathan (KVS) Schools and Patrachar Vidyalayas (PV) and Private (PVT) candidates, the pass percentage and compartment in Science with Practical examination was as follows :

Category of School	*Pass Percentage*	*Compartment (%)*
Government-aided	90.02	1.58
Government	82.53	1.65
Independent	98.28	0.20
JNV	98.73	0.42
KVS	97.72	0.52
PV/PVT	66.65	5.56

The highest percentage (38.18%) of students that scored 75% and above marks was from the category of Independent schools. It was followed by JNV (26.64%) and KVS (24.45%). Only 2.57% students from Government schools and 6.98% students from the Government-aided schools could score 75% and above marks in the subject. Science with Practical. The pass percentage (66.65%) of students from Patrachar Vidyalaya and that appeared as Private candidates was the lowest among all categories. Moreover, the least percentage (0.20%) of compartments is for Independent schools whereas highest percentage (5.56%) of compartments is for the category of Patrachar Vidyalaya and Private candidates.

Year 1999

Out of 412267 students that appeared in the Science with Practical examination, only 360677 (87.49%) students passed in the examination. The remaining either failed (12, 16%) or were placed in the compartment (0.16%). The result of 0.20% students was withheld.

The pass percentage of girls (89.12%) was higher than that of boys (86.31%). However the percentage (0.17%) of girls placed at the compartment was higher than that for the boys (0.15%). The mean mark for the girls (54.01) was slightly higher than that for the boys (53.4).

The percentage of students that scored marks in the range of 33-39% was 17.90% (girls — 19.13%, boys — 17.02%) whereas the percentage of students that scored 75% marks and above was 20.02 (girls — 20.04%, boys — 20.01%). The percentage (10.56%) of failures among girls was less than the percentage (13.31%) of failures among boys.

Among the various categories of schools such as Government aided, Government, Independent (public) JNV, KVS, PV and PVT candidates, the pass percentage and compartment in Science with Practical examination was as follows :

Category of School	*Pass Percentage*	*Compartment (%)*
Government-aided	86.36	0.11
Government	74.60	0.12
Independent	97.23	0.05
JNV	96.97	0.11
KVS	95.19	0.11
PV/PVT	57.59	1.05

The highest percentage (34.44%) of students that scored 75% and above marks was from the category of Independent schools. It was followed by JNV (23.81%) and KVS (21.18%). Only 1.94% students from the Government schools and 6.55% students from the Government-aided schools could score 75% and above marks in the subject Science with Practical. The pass percentage (57.59%) of students from Patrachar Vidyalaya and that appeared as Private candidates was the lowest among all categories. Moreover, the least percentage (0.05%) of compartment was for Independent schools whereas the highest percentage (1.05%) of compartments was for the category of Patrachar Vidyalaya and Private candidates.

Year 1998

Out of 385944 students that appeared in the Science with Practical examination, only 331550 (85.91%) students passed in the examination. The remaining either failed (13.71%) or were placed in compartment (0.32%). The result of 0.07% students was withheld.

The pass percentage of girls (86.96%) was higher than that of boys (85.14%). However, the percentage (0.45%) of girls placed at the compartment was higher than that for the boys (0.22%). The mean mark (55.3) was the same for both girls and boys.

The percentage of students that has scored marks in the range of 33.39% was 15.12% (girls — 16.57%, boys — 14.07%) whereas the percentage of students that scored 75% marks and above was 23.57 (girls — 23.37%, boys — 23.71%). The percentage (12.57%) of failures among girls was less than the percentage (14.55%) of failures among boys.

Among the various categories of schools, such as Government aided, Government, Independent (public), JNV, KVS, PV and PVT candidates, the pass percentage and compartment in Science with Practical examination was as follows :

Category of School	*Pass Percentage*	*Compartment (%)*
Government-aided	83.08	0.29
Government	70.0	0.31
Independent	97.70	0.04
JNV	96.53	0.15
KVS	95.20	0.13
PV/PVT	52.18	2.54

The highest percentage (40.0%) of students that scored 75% and above marks was from the category of Independent schools. It was followed by JNV (32.21%) and KVS (26.60%). Only 2.76% students from the Government schools and 8.82% students from the Government-aided schools could score 75% and above marks in the subject Science with Practical. The pass percentage (52.18%) of students from Patrachar Vidyalaya and that appeared as Private candidates was the lowest among all categories. Moreover, the least percentage (0.04%) of compartment was for Independent schools whereas the highest percentage (2.54%) of compartment was for the category of Patrachar Vidyalaya and Private candidates.

Performance of Students in Science at the Secondary Stage — Some Significant Data

Year	*Over-all Pass (%)*	*Pass Percentage of*						*Pass Percentage*		*Comp %*	*Fail %*	*Marks*				*Category schools from which highest no. of students obtained 75% and above marks*	*Category schools from which highest no. of students obtained marks between 33-39%*
												33-39%		*75% and above*			
		G-Ad	*GOV*	*IND*	*JNV*	*KVS*	*OTH*	*Boys*	*Girls*			*Boys*	*Girls*	*Boys*	*Girls*		
2000·	91.57	90.02	82.53	98.28	98.73	97.72	66 65	90.6	92.9	1.07	7.15 1.OTH (27 61%) 2.GOVT. (15.73%)	19.04	21.9	22.78	23.5	1.IND (38.18%) 2.JNV (26.64%)	1.OTH (40.87%) 2.GOVT. (39.76%)
1999	87.49	86.36	74.6	97.23	96.97	95.19	57.59	86.31	89.12	0.16	12.16 1.OTH (41.29%) 2.GOVT (25.23%)	17.02	19 13	20.01	20.04	1.IND (34.44%) 2.JNV (23.81%)	1.OTH (34.59%) 2.GOVT (33.11%)
1998	85.91	83.08	70	97.7	96.53	95 2	52.18	85.14	86.96	0.32	13.71 1.OTH (45.11%) 2.GOVT. (29.63%)	14.07	16.57	23.71	23.37	1. IND (40.00%) 2.JNV (32.21%)	1. GOV (26.69%) 2.OTH (27.04%)

Abbreviations used : G-Ad-GovernmentAided, GOV– Government, IND — Independent (Public) JNV - Jawahar Navodaya Vidyalaya, KVS — Kendriya Vidyalaya Sangathan, OTH — Patrachar + Private Candidates, Comp — Compartment.

Summary

- ☐ The performance of girls in comparison to that of boys for the years 2000, 1999 and 1998 has been better in respect of pass percentage, placement in compartment, scoring 75% marks and above (except 1998). The percentage of girls having scored marks between 33-39 has been higher than that of boys in all these years. The percentage of failures among girls has always been less than that for boys.
- ☐ There has been a continuous rise in the pass percentage in Science with Practical examination from 1998 (87.49%) to 2000 (91.57%).
- ☐ The performance of students from Government schools has been very poor in all these years, although there has been an improvement from 1998 (pass percentage 70.0) to 2000 (pass percentage 82.53). The percentage of their failure has been only next to students of Patrachar Vidyalaya and Private candidates, although there has been a marked decline from 1998 (percentage of failure 29.63) to 2000 (percentage of failure 15.73).
- ☐ The lowest pass percentage has been shown by students of Patrachar Vidyalaya and those appearing as Private candidates in all the three years, although there is improvement in their pass percentage from 52.18 (1998) to 66.65 (2000). However, the percentage of students placed at the compartment from this category is always the highest.
- ☐ The performance of students from the Independent schools has been the best. The pass percentage of the students is the highest, the percentage of students scoring 75 and above marks (both boys and girls) is the highest, and the percentage of students placed at the compartment is the lowest, varying from 0.04% (1998) to 0.20 (2000), in comparison with students from other categories such as JNV (1998 — 0.15%, 1999 — 0.11%, 2000 — 0.42%) and KVS (1998 — 0.13%, 1999 — 0.11%, 2000 — 0.52%).
- ☐ The fact that the overall pass percentage of the Board in 2000 has been 65.4% (boys — 65.6%, girls — 65.1%), whereas the overall pass percentage in Science with Practical in 2000 has been 91.57%. It is evident that the overall low pass percentage at the secondary examination during 2000 has not been due to failures in Science. It is subjects other than Science which have been responsible for the low pass percentage at the secondary examination in 2000.

Perhaps the higher percentage of compartment among the students of all categories of schools in the year 2000, in comparison to previous years, is because the Board has allowed compartment in *two* subjects, instead of *one*, as in previous years.

Mathematics

Year 2000

Out of 462747 students that appeared in the mathematics examination in the year 2000, only 326494 (71.98%) students passed in the examination. The remaining either failed (10.45%) or was placed in compartment (17.37%). The result of 0.20% students was withheld.

The pass percentage of girls (71.38%) was lower than that of boys (72 [illegible]%). However, the percentage of girls (18.98%) placed at the compartment was higher than that for the boys (16.18%). The average performance for the boys (43.2) was slightly higher than that for the girls (42.1).

The percentage of students that scored marks in the range of 33-39% was 18.30% (girls — 18.75%, boys — 17.97%) whereas the percentage of students that scored 75% marks and above was 15.74 (girls — 15.03%, boys (16.27%). The percentage (9.47%) of failures among girls was less than the percentage (11.16%) of failures among boys.

Among the various categories of schools, such as Government-aided, Government, Independent (public), JNV, KVS, PV and PVT students, the pass percentage and compartment in mathematics examination are given in the table below :

The highest percentage (27.47%) of students that scored 75% and above marks was from the category of Independent schools. It was followed by JNV (16.78%) and KVS (15.84%). Only 1.89% students from the Government schools and 4.81% students from the Government-aided schools could score 75% and above marks in the subject mathematics. The pass percentage (36.01%) of students from Patrachar Vidyalaya and that appeared as Private candidates was the lowest among all categories. Moreover, the least percentage (8.62%) of compartments was for Independent schools whereas highest percentage (34.37%) of compartments is for the category of Government schools followed by the Government-aided schools (28.18%)

Year 1999

Out of 423365 students appeared in the mathematics examination, only 296466 (70.03%) students passed in the examination. The remaining either failed (18.80%) or were placed in compartment (10.98%). The result of 0.19% students was withheld.

The pass percentage of girls (69.41%) was lower than that of boys (70.47%). However the percentage (12.70%) of girls placed at the compartment was higher than that for the boys (9.73%). The mean mark for the

Category of School	*Pass Percentage*	*Compartment (%)*	*Fail (%)*
Government-aided	62.70	28.18	9.09
Government	47.79	34.37	17.75
Independent	89.75	8.62	1.47
JNV	90.07	8.92	0.99
KVS	83.25	14.59	2.12
PV/PVT	36.12	18.91	44.94

girls (42.5) was also lower than that for the boys (44.0).

The percentage of students that scored marks in the range of 33-39% was 19.50% (girls — 20.38%, boys — 18.87%) whereas the percentage of students that scored 75% marks and above was 16.75 (girls — 15.41%, boys — 17.73%). The percentage (17.74%) of failures among girls was less than the percentage (19.57%) of failures among boys.

Among the various categories of schools such as Government aid, Government, Independent (public) JNV, KVS, PV and PVT students, the pass percentage and compartment in mathematics examination are given in the table below.

The highest percentage (29.38%) of students that scored 75% and above marks was from the category of Independent schools. It was followed by JNV (18.83%) and KVS (17.80%). Only 2.26% students from the Government schools and 6.26% students from the Government-aided schools could score 75% and above marks in the subject mathematics. The pass percentage (38.64%) of students from Patrachar Vidyalaya and that appeared as Private candidates was the lowest among all categories. Moreover, the least percentage (6.32%) of compartment was for Independent schools whereas the highest percentage (18.75%) of compartment is for the category of Government schools.

Year 1998

Out of 396848 students that appeared in the mathematics examination, only 284138 (71.60%) students passed in the examination. The remaining either failed (20.82%) or were placed in compartment (7.51%). The result of 0.07% students was withheld.

The pass percentage of boys (71.81%) was higher than that of girls (71.31%). However, the percentage (8.84%) of girls placed at the compartment was higher than that for the boys (6.53%). The mean mark for boys was (41.5) and for girls it was (40.2).

The percentage of students that has scored marks in the range of 33-39% was 21.32% (girls — 22.61%, boys — 20.36%) whereas the percentage of students that scored 75% marks and above was 12.66% (girls — 11.56%, boys 13.47%). The percentage (19.81%) of failures among girls was less than the percentage (21.57%) of failures among boys.

Category of School	*Pass Percentage*	*Compartment (%)*	*Fail (%)*
Government-aided	61.57	16.79	21.52
Government	42.68	18.75	38.53
Independent	89.18	6.32	4.13
JNV	87.23	8.81	3.93
KVS	81.66	11.27	7.04
PV/PVT	38.64	10.03	51.27

Performance of Students in Mathematics at the Secondary Stage — Some Significant Data

Year	Over-all Pass (%)	Pass Percentage of						Pass Percentage		Comp %	Fail %	Marks				Category schools from which highest no. of students obtained 75% and above marks	Category schools from which highest no. of students obtained marks between 33-39%
		G-Ad	GOV	IND	JNV	KVS	OTH	Boys	Girls			33-39% Boys	33-39% Girls	75% and above Boys	75% and above Girls		
2000	71.98	62.7	47.79	89.57	90.07	83.25	36.01	72.42	71.38	17.37	10.45% 1.OTH (44.94%) 2.GOVT. (17.75%)	17.97	18.75	16.27	15.03	1. IND (27.47%) 2.JNV (16.78%)	1.G-Ad (27.12%) 2.GOVT. (25.27%)
1999	70.03	61.57	42.68	89.18	87.23	81.66	38.64	70.47	69.41	10.98	18.80 1.OTH (51.27%) 2.GOVT. (38.53%)	18.87	20.38	17.73	15.41	1.IND (29.38%) 2.JNV (18.83%)	1.G-Ad (25.36%) 2.GOVT (22.64%)
1998	71.6	60.35	42.66	92.34	90.93	86.74	36.74	71.81	71.31	7.51	20.82 1.OTH (55.53%) 2.GOVT. (42.78%)	20.36	22.61	13.47	11.56	1. IND (23.25%) 2.JNV (15.19%)	1.G-Ad (32.75%) 2.OTH. (26.84%)

Abbreviations used : G-Ad-Government Aided, GOVT.- Government, IND — Independent (Public) JNV — Jawahar Navodaya Vidyalaya, KVS — Kendriya Vidyalaya Sangathan, OTH - Patrachar + Private Candidates, Comp — Compartment

Among the various categories of schools such as Government aided, Government, Independent (public) JNV, KVS, PV and PVT candidates, the pass percentage and compartment in mathematics examination are given in the able below.

The highest percentage (23.25) of students that scored 75% and above narks was from the category of Independent schools. It was followed by JNV 15.19%) schools and KVS (13.77%). Only 2.35% students from the Government aided schools could score 75% and above marks in the subject mathematics. The pass percentage (36.47%) of students from Patrachar Vidyalaya and that appeared as Private candidates was lowest among all categories. Moreover, the least percentage (3.45%) of ompartment is for Independent schools whereas the highest percentage (14.51%) of compartment is for the category of Government schools.

Summary

- The performance of boys in comparison to that of girls for the years 2000, 1999 and 1998 has been **better** in respect of pass percentage. However, the compartmental cases of boys were more in 1999 and 1998 than girls. But in 2000, number of compartment cases of boys was less than those of girls.
- The Board results have further revealed better performance of boys in securing 75% marks and above in the years 2000, 1999 and 1998 while percentage of girls securing marks in the range of 33-39% is higher than that of boys. The percentage of failures among girls has been less than that of boys.
- The performance of students of government schools has been very poor in all these years, although there has been an improvement from 1998 (42.66%) to 2000 (47.79%) and the percentage of failures shows a remarkable decline from 42.78% in 1998 to 17.75% in 2000.
- The performance of the students from government-aided schools has shown consistent improvement in all the three years. [1998 (60.35%) to 2000 (62.70%)]

ategory of School	*Pass Percentage*	*Compartment (%)*	*Fail (%)*
overnment-aided	60.35	14.09	25.55
overnment	42.66	14.51	42.78
ndependent	92.34	3.45	4.15
NV	90.93	4.07	4.98
VS	86.74	5.13	8.03
V/PVT	36,47	7.86	55.53

Reference Electrodes and their Exchange Current Density (i_0) Values

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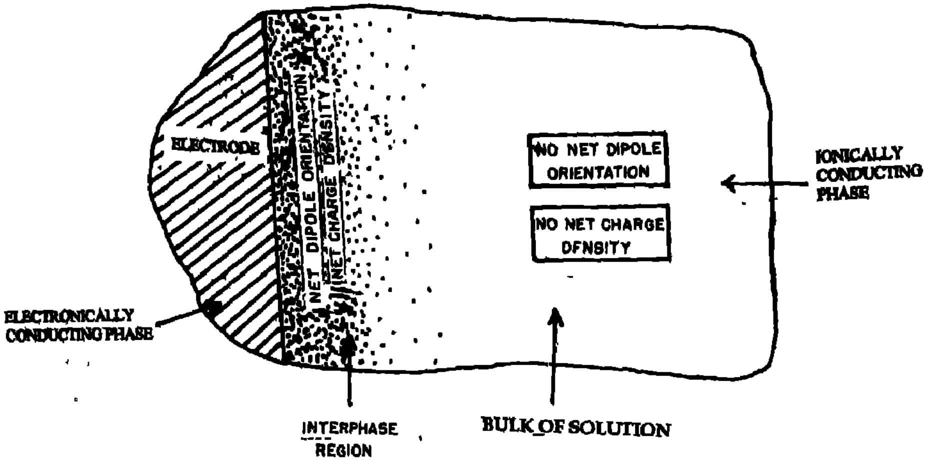
In the measurement of electrode potential, whether for thermodynamic data or in electrodics or electrode kinetics, a reference potential is necessary. Electrodics or electrode kinetics deals with the transfer to charge across electrically charged interfaces. According to Bockris and Reddy the term is used to express charge transfer between an electric conductor (say, a metal electrode) and the solution phase (electrolyte) in immediate contact. This is due to the fact that potential of a single electrode cannot be measured and it has to be done by combining with another electrode[1] whose potential remains steady over a range of time. In fact, a reference electrode should not draw any net current. Due to this property, reference electrodes are used in the measurement of equilibrium constant, pH, activity and activity coefficient and in potentiometric titrations[2-4]. In the electrode process studies, they are an intrinsic part of the electrochemical system itself. However, the theoretical considerations behind the selection of reference electrodes have not been discussed fully in most of the textbooks in physical and analytical chemistry.

In general, the textbooks treat these electrodes as simply reversible electrodes without citing the mechanism of



reversibility, which is one of the basic factors governing the suitability of a reversible electrode for use as a reference electrode[5]. Experimentally it has been observed that from a wide range of reversibly electrodes, only few can be used as a reference electrode. It is, therefore, essential to understand the characteristics that a reversible electrode must possess in order that it could be utilized as a reference electrode.

Furthermore, suitability of a reference electrode depends on its exchange current density. (i_0), variation of potential with concentration (activity) as given by Nernst equation and reproducibility and stability of the potential. Besides these, choice of reference electrode depends on nature of the measurement also. In thermodynamic studies, high accuracy and stability is required which may be relaxed in electrode kinetic work[6]. Keeping the above factors into consideration, an attempt is being made here to evaluate the various types of the reference electrodes and their suitability in relation to current density (i_0) values.

Theoretical Consideration

Reference electrodes are basically the reversible electrodes having high value of exchange current density, (i_0), which is an indicator of the level of reversibility. As we know, in a reversible electrode, under the state of equilibrium, no current flows across the metal-solution interface. There is no net occurrence of electrochemical reaction, only a dynamic equilibrium exists. A process of electronation and de-electronation takes place at the same rate and takes the same time. The current corresponding to these processes are equal in magnitude but opposite in direction—

$$\vec{i}_e = \overleftarrow{i}_{de} \qquad \ldots (1)$$

Potential difference across the interface corresponds to equilibrium potential under the dynamic equilibrium. The individual electronation and de-electronation currents under the situation are designated as the equilibrium exchange current density, (i_0), which is related to the equilibrium potential by the equations.

$$i_0 = \vec{i}_e = F\vec{k}C_A{+}e^{-\beta F\Delta\phi_e/RT} \qquad \ldots(2)$$

$$= \overleftarrow{i}_{de} = F\overleftarrow{k}C_D{+}e^{(1+\beta)F\Delta\phi_e/RT} \qquad \ldots(3)$$

Where

$\vec{k}$ = specific reaction rate of electronation process

$\overleftarrow{k}$ = specific reaction rate of de-electronation process

C_A+ = Concentration of reactant in the electronation process

C_D = Concentration of reactant in the de-electronation process

$\Delta\phi_e$ = Equilibrium potential

β = Symmetry factor for the electrochemical process and F, R and T symbolises Faraday, Gas Constant and temperature in Kelvin scale respectively.

Significance of Equilibrium Current Density i_0

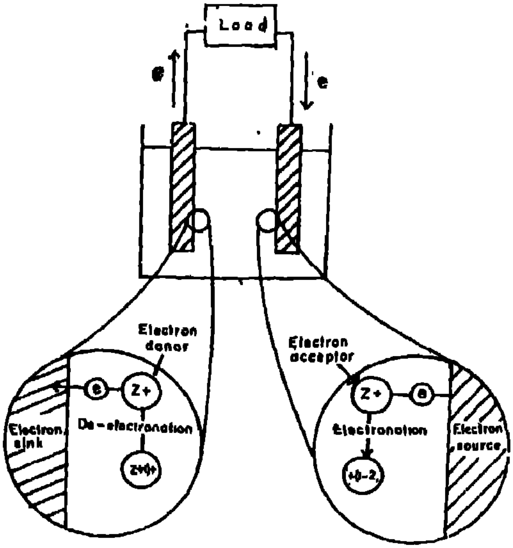
It was shown by Butler[7] that an equality of this type i.e. $\vec{i}_e = \overleftarrow{i}_{de}$ generally lead to the development of a potential, the equilibrium potential $\Delta\phi_e$. The currents

$\vec{i}_e$ and $\overleftarrow{i}_{de}$ at the eqilibrium state are in fact measure of reactions occurring at the interface in opposite direction but at equal rates. They express the rate of two-way electron traffic between electrode and particles (ions) in the electrolyte, while there is no net charge transfer from one phase to other. Since they are numerically equal they are designated by equilibrium exchange current density i_0.

Exchange current density, i_0 reflects the kinetic properties of the particular electrode-electrolyte interfacial system and varies from electrode to electrode. It depends on the values of $\Delta\phi_e$, $\vec{k}$, $\overleftarrow{k}$, C_A+ and C_D of the system. It characterises the kinetics of ion exchange of the interface under equilibrium condition. The equations 1 and 2 are the relations between equilibrium potential, $\Delta\phi_e$ and i_0 for the reversible electrodes and indicate that under the equilibrium state, electrode potential reaches $\Delta\phi$ value with an equilibrium current density i_0 flowing across the interface.

Since the rates of electronation and de-electronation are equal under the equilibrium state, the charge on the metal with respect to the solution are independent of time and, therefore, the electrode potential remains steady and time invariant[8]. The electrode potential remains at the equilibrium value so long the current density across the electrode-electrolyte interface does not exceed i_0. However, the exchange current density i_0 can not be measured directly since there is no net current flowing across the interface under equilibrium condition. But it can be determined indirectly by polarizing the electrode and extending the polarization plot to the equilibrium potential[9,10].

While considering the reversible electrodes, their non-polarizable nature should not be forgotten. The electrode potential does not change easily with the passage of current due to non-polarizing interface. This non-polarizable property of the interface depends on i_0 value of the charge transfer reaction occurring at the electrode[11], i.e. i_0 determines the degree of polarizability of the electrode. It determines the current density beyond which the electrode potential will deviate from its equilibrium value. If the exchange current density, i_0 tends to be very high value i.e. $i_0 \rightarrow \infty$, then the interface will remain at its equilibrium potential even on passing very high current through it.



The above criterion suggests that higher the exchange current density, i_0, the less does the potential difference across an interface departs from the equilibrium potential on passage of current. Furthermore, the ideally non-polarizable interface is always at equilibrium and at its equilibrium potential. This is of course an ideal situation. But in reality, all the electrodes whatever may be the nature of the charge transfer reaction occurring at their surface, have some finite i_0 value, which means that all the electrodes have some degree of polarizability. And larger the value of i_0, the greater will be the current density required to produce a given change of potential from the equilibrium value. Therefore, a good quality reversible electrode should have high i_0 besides the other criteria mentioned earlier.

i_0 Value of Some Reversible Electrodes and their Analysis

The preceding section provides the basic requirements for analysing a reversible electrode and judge its suitability as

Table 1
Exchange Current Density, i_0 for Some Reversible Electrodes

Electrode system	*Electrode reaction*	*Solution composition*	*Standard electrode Potential E(V)*	*Exchange Current density i_0 (A cm^{-2})*	
Ni^{2+}/Ni	$Ni^{2+} 2e^- \rightarrow Ni$	2N $NiSO_4$	−0.250	2×10^{-9}	12
Fe^{2+}/Fe	$Fe^{2+} + 2e^- \rightarrow Fe$	2N Fe SO_4	−0.4402	1×10^{-8}	12
Cu^{2+}/Cu	$Cu^{2+} + 2e^- \rightarrow Cu$	2N Cu SO_4	+0.337	2×10^{-5}	12
Zn^{2+}/Zn	$Zn^{2+} 2e^- \rightarrow Zn$	2N Zn SO_4	−0.7628	2×10^{-5}	12
Cd^{2+}/Cd	$Cd^{2+} + 2e^- \rightarrow Cd$	Cd SO_4	−0.4029	2×10^{-3}	13
Ag^{+}/Ag	$Ag^{+} + e^- \rightarrow Ag$	1N Ag NO_3	+0.7991	2×10^{-2}	13
Hg_2^{2+}/Hg	$Hg_2^{2+} + 2e^- \rightarrow 2Hg$	2, $\times 10^{-3}$ N $HgNO_3$+2.ON $HClO_4$	+0.788	2×10^{-1}	12
H^+/H_2,Pd	$H^+ + e^- \rightarrow 1/2H_2$	0.1N HCl	0.059	5.6×10^{-4}	14
H^+/H_2,Pt	$H^+ + e^- \rightarrow 1/2\ H_2$	1N HCl	0.0	1×10^{-3}	14
Ce^{4+},Ce^{3+},Pt	$Ce^{4+} + e^- \rightarrow Ce^{3+}$	–	1.61	3.9×10^{-5}	7
Fe^{3+},Fe^{2+},Pt	$Fe^{3+} + e^- \rightarrow Fe^{2+}$	–	0.77	2.5×10^{-3}	7
Cl^-/Hg_2Cl_2,Hg	$Hg_2Cl_2 + 2e^- \rightarrow 2Hg + 2Cl^-$	Satd KCl	0.2412	$= 6 \times 10^{-1}$	12
Cl^-/AgCl,Ag	$AgCl + e^- \rightarrow Ag + Cl^-$	1N KCl	0.224	$= 2 \times 10^{-2}$	13

a reference electrode. In the table below are listed the exchange current densities of some reversible electrodes and the processes involved therein.

The reversible electrodes cited in the table given on page 25 have i_0 values, ranging from 10^{-9} A cm^2 to 5×10^{-1}A cm^{-2} and cover different types of the electrodes. Out of these, $Pt/H_2/H^+$, $Hg/Hg_2Cl_2/Cl^-$ and $Ag/AgCl/Cl^-$ are the most widely used reference electrodes. These electrodes have high i_0 values i.e. approximately 10^{-3} A cm^{-2}, α 5×10^{-1}A cm^{-2} and 10^{-2}A cm^{-2} respectively besides their potentials being stable and reproducible.

Amongst the M^{+n}/M electrodes, Ag^+/Ag, Hg_2^{2+}/Hg and Cd^{2+}/Cd electrodes have also high i_0 values. Cd^{2+}/Cd electrode is used in Weston cadmium cell as an amalgam electrode. Ag^+/Ag electrode has although high i_0 value but due to corrosion of Ag metal in aqueous system, it does not show reproducible and stable potential on prolonged use. However Ag^+/Ag has been suggested by Gilead et al.[15] for propylene carbonate using $AgClO_4$ and $LiClO_4$ as electrolyte. Hg_2^{2+}/Hg electrode competes with $Hg/Hg_2Cl_2/Cl^-$ electrode in i_0 value but due to poisoning action of Hg_2^{2+}, this electrode is not used as reference electrode although it meets all the requirements for a good reference electrode.

The redox electrodes, $Pt/Ce^{4+}, Ce^{3+}$ and $Pt/Fe^{3+}, Fe^{2+}$, have 3.98×10^{-5}A cm^{-2} and 2.5×10^{-3}A cm^{-2} i_0 values respectively. The former has very low exchange current density to be considered for reference electrode and the later i.e. $Pt/Fe^{3+}, Fe^{2+}$ has of course suitable i_0 value. But these electrode systems can not be used as reference electrodes due to their irreproducible potential, caused due to oxidation of their ion.

From the electrode systems discussed, it is amply evident that for a reference electrode, exchange current density, i_0 is as important as its potential stability and reproducibility. A good reference electrode should have high i_0 as it will ensure stability of the potential during measurement or on connecting to a potentiostat for electrochemical studies.

Conclusion

Selection of a reference electrode should be based on its exchange current density (i_0), and not only on reproducibility and stability of potential and its variation with reversible ions concentration. A good reference electrode must possess high i_0 so that its potential does not depart from equilibrium value, given by Nernst equation, when connected to a circuit for potential or electrochemical kinetic studies.

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The Mysterious Infinity

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The concept of endlessness of numbers arises very early when a child in fact learns about the numbers like 1, 2, 3, ... etc. called natural numbers. A precocious child can argue whether there is any largest natural number. He can build up his argument by assuming that he has found the biggest number N. However, just by adding 1 to N will fetch him another number, N+1, which is still bigger. In this way, he will finally end up with the concept of numerousness of endlessness of numbers.

This endlessness is what the mathematicians have named infinity. It isn't a number like 1, 2 or 3. In fact, it is hard to say what it is exactly. It is even harder to imagine what would happen if one tried to manipulate it using the arithmetic operations that work on numbers. For example, what if one multiplies it by 2 ? Is 1 plus infinity greater than, less than, or the same size as infinity plus 1 ? What happens if one subtracts 1 from it ? These and many other related questions centre round the weird concept of infinity, which has a mysterious realm of its own.

The usual symbol for infinity is ∞. This symbol was first used in a seventeenth century treatise on conic sections. It caught on quickly and was soon used to symbolise infinity or eternity in a variety of contexts.

The appropriateness of the symbol ∞ for infinity lies in the fact that one can travel endlessly around such a curve called leminiscate (Fig. 1). Endlessness is, after all, a principal component of one's concept of infinity. Other notions associated with infinity are indefiniteness and inconceivability.

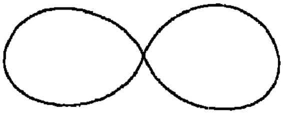

Fig. 1

In the physical world there are various sorts of infinities that could actually exist e.g. infinite time, infinitely large space, infinite-dimensional space, infinitely continuous space etc. Georg Cantor, a German mathematician, has dubbed such infinities physical infinities. In addition to these infinities, Cantor also defines two other types of infinities. These are Absolute Infinite and mathematical infinities.

Cantor, in fact, allowed for many intermediate levels between the finite and the Absolute infinite. These intermediate stages correspond to what Cantor called *transfinite* numbers, that is, numbers that are finite but nonetheless conceivable.

The word 'Absolute' in the context or Absolute infinite is used in the sense of 'non-relative, non-subjective'. An Absolute exists by itself and is the highest possible degree of completeness (in religion, this Absolute corresponds to God !).

Cantor introduced the concept of sets and showed that only real numbers can be expressed in terms of infinite sets. A set, as defined by mathematicians, is any collection of distinct or well-defined objects of any sort—people, pencils, numbers. Different objects such as a book, a football, a glass and a table can also constitute a set. The objects constituting a set are called its elements or members. An infinite set is one whose number of elements cannot be counted.

Let us define N as the finite set of all natural numbers :

N = {1, 2, 3, 4, ...}

If we remove from N the infinite set of odd natural numbers, then we will be left with the infinite set of even natural numbers :

E = {2, 4, 6, 8, ...}

Similarly, taking away from N the infinite set of even natural numbers leaves us with the set of odd natural numbers :

O = {1, 3, 5, 7, ...}

So, we see that when an infinite subset is removed from an infinite set the result is an infinite set. Now, consider the infinite set of all natural numbers starting from, say, 11 onwards and remove it from the infinite set of all natural numbers. You will be left with the finite set of first ten natural numbers. Thus, removing an infinite subset from an infinite set can also result in a finite subset.

The set of natural numbers and the set of odd (or even) natural numbers are both finite. But, which of the two represents bigger infinity ? If we attempt to count the number of odd natural numbers by the usual way, then we find that a one-to-one correspondence exists between the natural numbers and the odd natural numbers. This means that corresponding to every natural number n there exists an odd natural number 2n–1 :

$$\begin{array}{cccccccc} 1 & 2 & 3 & 4 & 5, & \ldots, & n, & \ldots \\ \updownarrow & \updownarrow & \updownarrow & \updownarrow & \updownarrow & & \updownarrow & \\ 1 & 3 & 5 & 7 & 9, & \ldots, & 2n-1, & \ldots \end{array}$$

Thus, the number of odd natural numbers is infinite and equal to the number of natural numbers. This is expressed by saying that the *cardinality* of the set of odd natural numbers is the same as the set of all natural numbers. These two sets, therefore, represent the same infinity.

It can be easily seen that the set of perfect squares has also the same cardinality as the set of natural numbers :

$$\begin{array}{cccccccc} 1 & 2 & 3 & 4 & 5, & \ldots, & n, & \ldots \\ \updownarrow & \updownarrow & \updownarrow & \updownarrow & \updownarrow & & \updownarrow & \\ 1 & 4 & 9 & 16 & 25, & \ldots, & n^2, & \ldots \end{array}$$

Similarly, the sets of cubes, fourth powers, fifth powers etc. of natural numbers can be seen to have the same cardinality as the set of natural numbers. All these sets, therefore, represent the same infinity.

It can be shown that even the set of all rational numbers has the same cardinality as the set of natural numbers. We can list all the rational numbers by first displaying them in an array. Along the first row we list all those which have numerator 1, along the second row all those with numerator 2, along the third row all those with numerator 3, and so on (Fig. 2).

$$\begin{array}{cccccc}
\frac{1}{1} & \frac{1}{2} & \frac{1}{3} & \frac{1}{4} & \frac{1}{5} & \cdots \\
\frac{2}{1} & \frac{2}{2} & \frac{2}{3} & \frac{2}{4} & \frac{2}{5} & \cdots \\
\frac{3}{1} & \frac{3}{2} & \frac{3}{3} & \frac{3}{4} & \frac{3}{5} & \cdots \\
\frac{4}{1} & \frac{4}{2} & \frac{4}{3} & \frac{4}{4} & \frac{4}{5} & \cdots \\
\frac{5}{1} & \frac{5}{2} & \frac{5}{3} & \frac{5}{4} & \frac{5}{5} & \cdots \\
\cdots & & \cdots & & \cdots & \cdots
\end{array}$$

Fig. 2

Now, if we decide to count row by row then we will be exhausting all the natural numbers by one-to-one correspondence with the entries in the first row. It might seem therefore that because there are an infinity of rows, there must be more rational numbers than natural numbers.

However, we can arrange to count in a different way, beginning with $\frac{1}{1}$, continuing with the rational numbers whose numerator and denominator add upto 3, then with those whose numerator and denominator add upto 4, and so on. This gives us a diagonal method of counting (Fig. 3).

It is clear that this arrangement of diagonal counting enables us to list all the natural numbers. The fact that some of them occur more than once in different forms such as $\frac{1}{1}, \frac{2}{2}, \frac{3}{3}, \ldots$ and $\frac{1}{2}, \frac{2}{4}, \frac{3}{6}, \ldots,$ does not affect the force of the argument.

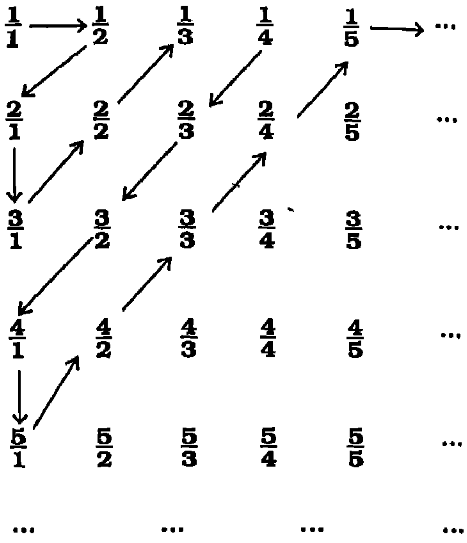

Fig. 3

In this manner, all the rational numbers can be counted i.e. they can be put into one-to-one correspondence with the natural numbers. There are therefore the same number of rational numbers as there are natural numbers. So, the set of rational numbers has the same cardinality as the set of natural numbers.

We may denote the infinity of natural numbers by N_0 (Cantor used the Hebrew letter $\aleph_0$ (aleph-null) to denote this infinity). We say that the set of natural numbers has the same cardinality N_0.

We have seen that the sets of all odd and all even natural numbers have the same cardinality (or infinity) as the set of all natural numbers. Thus, the sets of odd and even natural numbers have N_0 members each. As the sets of odd and even natural numbers together go to make up the set of natural numbers we have : $N_0 + N_0 = N_0$

This defies the dictum applicable to finite collections that 'a part cannot be equal to the whole'. A strange result : isn't it ? But, an infinite collection (set) is a collection of objects equal in number to only a part of itself.

Let us now consider a real number i.e. a number expressible in the form :

$\pm n.r_1r_2r_3r_4$

where n is any natural number and r's are digits from 0 to 9. This decimal may be finite and terminating, or may be non-terminating but recurring, or may be non-terminating and non-recurring. Cantor expressed real numbers in terms of infinite sets and showed that the real numbers cannot be put in one-to-one correspondence with the natural numbers. Thus, the infinity or cardinality of real numbers is not the same as that of natural numbers.

If we define the infinity of real numbers by N_1 then we can say that N^1 is greater than N_0 provided that we take care in defining precisely what we mean by 'greater than' in the context of infinite numbers. We do this by noting that whereas N_0 numbers can be put in one-to-one correspondence with any part of the N_1 real numbers, there is no way in which N_1 numbers can be put in one-to-one correspondence with a part of N_0 numbers. This applies, of course, to any collection of N_0 and N_1 objects. It is a fundamental truth of what we call 'set theory', the general theory which derives from Cantor's work, and is not confined to collections of numbers.

Numbers such as N_0 and N_1 are called 'transfinite' i.e. they are beyond the finite yet there are infinitely many of them. This was proved by Cantor by showing that given any number, finite or transfinite, it is always possible to construct one that is greater.

Thus, as proved by Cantor, an infinite number of transfinite numbers viz. N_0, N_1, N_2, ... etc. can exist. We, therefore, have an infinity of infinities. But, can there also exist an infinity between N_0 and N_1, between N_1 and N_2 between N_2 and N_3, and so on. According to Cantor's *continuum hypothesis* there is no infinity in between. Generalising the hypothesis we can say that no infinity can exist between N_k and N_{k+1}.

Cantor's work has now received proper recognition. However, initially, it was put to severe criticism. Some of his contemporaries described his set theory as 'a disease', 'repugnant to common sense', and so on. These attacks depressed Cantor and led to a series of nervous breakdowns. This genius died in 1918 in a mental institution in Halle. The following remarks about infinity made by Cantor deserves special mention:

"The fear of infinity is a form of myopia that destroys the possibility of seeing the actual infinite, even though it in its highest form has created and sustains us, and in its secondary transfinite forms occurs all around us and even inhabits our minds".

Microscale Experiments in Inorganic Chemistry

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INORGANIC Chemistry Experiments like gravimetric and volumetric exercises, qualitative analysis and preparations form a major part of the syllabii of practical chemistry at undergraduate level. They consume a major share of chemicals used in laboratory. The ever rising cost of chemicals is adversely affecting the practical exercises. The fumes and gases evolved during chemical reactions are threatening the environment. The awareness for eco-friendly environment is becoming a global phenomenon. It is in this context, that a need has arisen which was never so acute herebefore, that the laboratory chemicals be used at a minimal level without affecting the skill and understanding of a student performing the practical. The 'Geeta' of chemical analysis by Vogel prescribes the use of about 0.2 gram chemical for every test of the qualitative analysis. Volumetric and gravimetric experiments use 25 ml and 50 ml volumes of solutions. Preparations are done on 5 to 7 gram scale. These things seem to be out of date in the present context and need a drastic revision.

We have adopted a scheme without any conceptual deviation of the principles of analysis to reduce the consumption of chemicals. It uses the same conventional apparatus but on a smaller size. This scheme saves time and energy of a student while performing the experiments. It also offers economy of fuel. We found it to be successful at student level. The scheme can be introduced even for the students of Classes XI and XII. A student of Class XI, within a span of five years i.e. by the time he completes his B.Sc., would have developed expertise in chemical analysis and would be ready to handle problems in chemical analysis in a modern way.

The Environmental Angle

The environment of the chemistry laboratories in general is highly polluted and contaminated. This is mainly due to variety of chemicals used, the reactions that give rise to evolution of toxic gases, fumes of solvents, vapours of acids and ammonia and low boiling liquids. For years, our laboratories have been polluting the environment by releasing the waste into drainage and also by generation of gases which escape into atmosphere. Most of us working for long years in the laboratories are unknowingly affected. The complaints like acidity, headaches, ulcers and allergies are very common. The measures like fitting exhaust fans, hoods, etc. are not very effective. The better management would therefore require controlling the very amount of effluents, pollutants and contaminants that are produced as by-products of the experiments performed in the laboratory. This requires a strong desire to develop a proper mind set for all those who are concerned i.e. the teachers, students and the attendants. It is thus a team work.

A test like that of testing nitrate or chloride requires use of conc. sulphuric acid. We found that the test like these can be performed on 1 drop scale effectively and efficiently whereas one uses 1 and 2 ml of acid for this today. Similarly titrations can be done on 10 or 5 ml or even on smaller scale using 0.05N or 0.01N solutions. Hydrogen sulphide is another reagent that is produced in large amounts in the laboratory. If the reagent is used to precipitate the sulphide from large volume of solution obviously large volume of gas is released to the atmosphere. The same reaction if done on scale down proportion say 1 ml, the quantity that will be required will be reasonably low. This will help to maintain healthy atmosphere in the laboratory.

Inorganic Qualitative Analysis Scale

Type	*Quantity*	*Volume*
Macro analysis	0.5 to 1.0 g	20 ml
Semi micro	50 mg	1 ml
Micro	5 mg	0.5 ml

Pre-note

According to Vogel's own statement :

"There is no sharp line of demarkation. Only the scale of operation is reduced. Concentration remains the same."

"Special experimental techniques are required for handling small volumes and small amount of ppt."

"Macro qualitative is good for beginners but as they grasp it should scale down gradually to semimicro or micro level."

Let us consider, as an example, the experiment of qualitative analysis.

As on Today

Inorganic qualitative analysis is introduced to students at Class XI level. These students are taught to analyse a single compound. Each student analyses 8 to 10 substances in the first year. In the next year i.e. in Class XII, the scheme of mixture analysis is introduced. These students analyse 8 to 10 mixtures (either basic or acidic radicals). The scale of analysis is macro level. At first and second year B.Sc. levels, the students perform full qualitative analysis of a binary mixture. They analyse about 4 to 6 mixtures. At final year B.Sc. level the students analyse about 6 mixtures with or without phosphate or borate radicals. Thus students are exposed to the techniques of qualitative analysis for all these years. In fact, the scheme of scaled down or semi-micro analysis can be introduced at the first year of B.Sc. as they know by that time the working on macro level. However, traditionally the practicals conducted in most colleges allow students to use 5 to 6 gram of mixture. Given an allowance to repetitions, wastage, spillovers and accidental breakage of apparatus, the consumption of mixture per student can be averaged out to about 8 grams.

Consumption Pattern Today

As an example, let us consider the consumption in the laboratory for conducting inorganic qualitative analysis for the third year of B.Sc.

Let us say that there are 80 students in this class. Each student consumes about 8 grams mixture and he analyses about 6 mixtures during the year. Thus about 4 kg of mixture is required.

Besides the chemicals for making mixtures, the other laboratory requirements are reagents, acids, ammonia, alkalies, solvents, fuel, electrical energy and glassware. For final year of B.Sc. alone, we require 60 odd chemicals, 100 litres of HCl., 100 litres of H_2SO_4, 20 litres of HNO_3, 100 litres of NH_3, 30 kg of FeS. This shows that qualitative analysis is the major consumption factor.

Expenditure Today

Class	*Strength*	*Approx. Amount Spent (in Rs.)*
B.Sc. (III)	80	45,000 to 50,000
B.Sc. (II)	200	35,000 to 40,000
B.Sc. (I)	400	40,000 to 45,000
Junior College (Classes XI and XII)	1500	45,000 to 50,000
Total		**1,65,000 to 1,85,000**
+ Fuel		**50,000**

Advantages in Scaled Down Analysis

- Reduced consumption of chemicals and saving of cost
- Greater speed of analysis
- More efficient method
- Reduction in air pollution/water pollution
- Develops experimental skill

No serious difficulty should be encountered in switching from macro to semi-micro or micro level.

Our Initiative

Our initiative in scaling down the quantity arose as a curiosity. We first carried out ourselves the experiments in inorganic chemistry using small quantities of solids and solutions. Then we checked whether this scheme can be used at the student level. We succeeded in that. We then started practising it in our own college for classes from first to third year of B.Sc.

We made an important observation that students developed the required mind set and tried to use as minimum as possible the mixtures, solutions, reagents and solids. It saved their time and energy while for us it became cost effective.

In last few years, we conducted workshops at different places like Vivekananda College, Kolhapur, Gogate College, Ratnagiri, Walchand College, Solapur, Wadia College, Pune University, Department of Chemistry, Pune. Several college teachers from University areas of Pune, Mumbai, Uttar Maharashtra, Nagpur, Aurangabad, Shivaji attended these workshops. These teachers are convinced that experiments could be done on 'scale down' basis without affecting their principles and procedures. This scheme saved time, energy, chemicals and encouraged the students and teachers to use the remaining time to do other experiments.

What Next ?

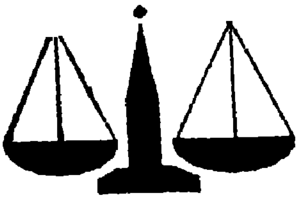
We have approached the Maharashtra State Board of Higher Education and requested the authorities to introduce the scheme of 'Microscale Experiments in Chemistry' for the students of classes XI and XII. The Board has accepted the scheme in principle and has also run a workshop on a pilot scale at Vivekananda College, Kolhapur. Considering the favourable response from teachers, it is likely that the scheme will be introduced by the Board for the students of Classes XI and XII during the next revision of the syllabus. The Pune University has introduced the 'scale down' procedures in the experiments of organic chemistry at the undergraduate level. The Goa University is considering the implementation of it. In the ne future, it is expected that some mo universities will introduce the 'sca down' procedures in the experiments undergraduate level.

Conclusion

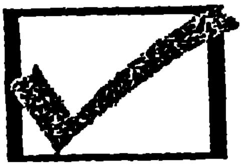
The scaling down of quantities of chen cals and reagents will eventually sa the expenditure, time, energy and fu The understanding of the students w be much better as they develop keen interest and sense of observation th before.

THE NEED

- **MANAGING THE BUDGET AGAINST INFLATING COST**

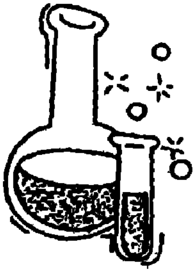


- **OPTIMISING THE ENERGY CONSUMPTI**



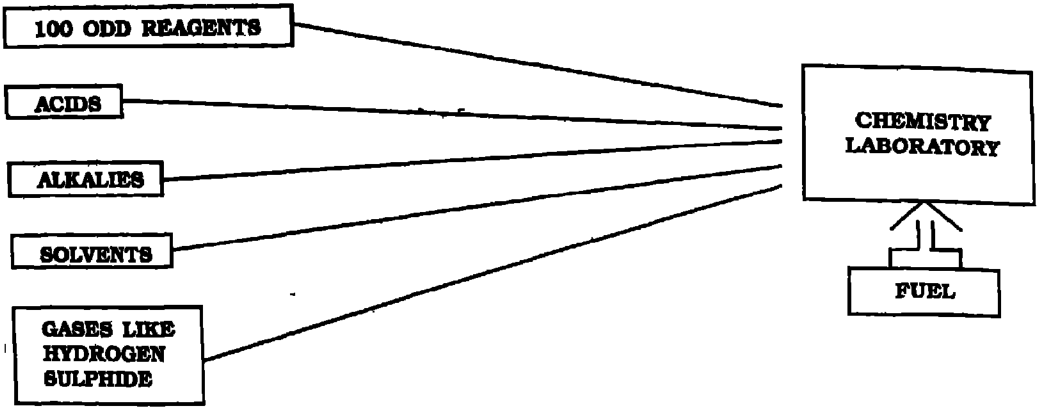
- **CLEANER AND HEALTHIER ENVIRONMENT**

- **SAVING TIME AND IMPORTANT RESOURCES**

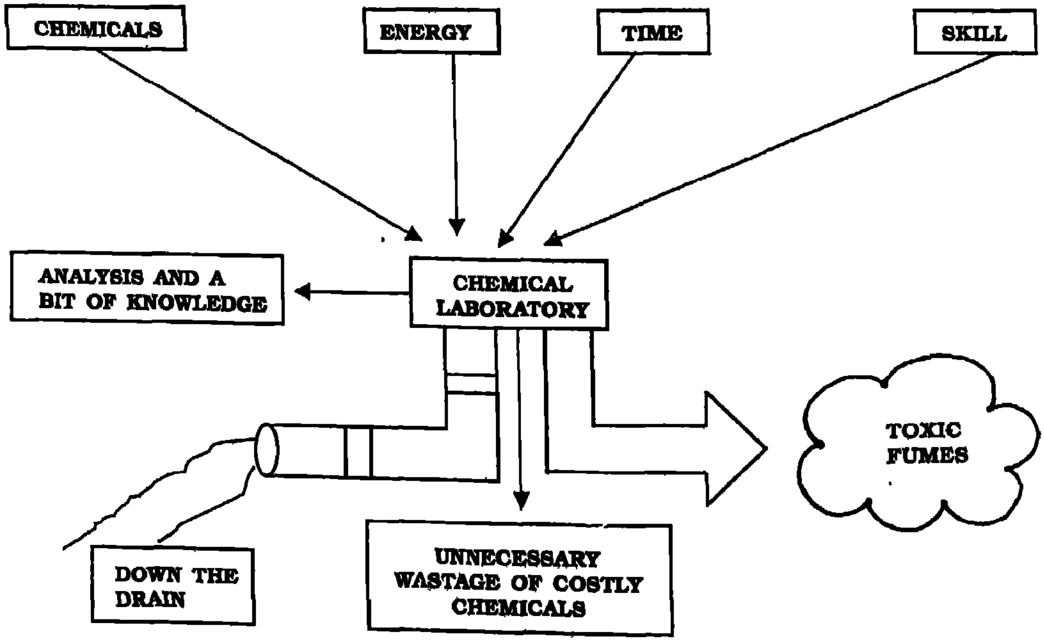


- **BETTER UNDERSTANDING OF SUBJECT**

THE COST OF RUNNING CHEMISTRY DEPARTMENT



CHEMICAL LABORATORY, COST BENEFIT AND POLLUTION — AT A GLANCE


CHEMICALS
ENERGY
TIME
SKILL
ANALYSIS AND A BIT OF KNOWLEDGE
CHEMICAL LABORATORY
TOXIC FUMES
DOWN THE DRAIN
UNNECESSARY WASTAGE OF COSTLY CHEMICALS

Cube-Roots through Calculator

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MOST OF the ubiquitous pocket-calculators are equipped with a key for the square-root, but not for the cube-root. Here, I venture to suggest a simple way to get a satisfactory value of the cube-root of a number, using only the pocket-calculator.

We recall that the infinite geometric series

(1/4) + (1/16) + (1/64) + (1/256) + (1/1024) + ... has the sum 1/3. If the given number is N, we "punch" N, and then press the square-root key TWICE. This displays the fourth-root of N. We either store the same in the memory (if provided for) or, record it on a piece of paper. We next press the same key TWICE MORE. This results in the sixteenth-root of N. Having recorded this, we repeat the process several times more, depending on the accuracy expected. Finally, we multiply out all the recorded numbers, to get the cube-root of N.

As an example, let us calculate the cube-root of 7. From the table of cube-roots, we find that it has the value 1.9129. When we cube the same, we get 6.9996576. If we follow the procedure given above, we arrive at the following figures :

Number of steps	*Value of the cube-root of 7*	*Cube of the value in column II*
3	1.8936412	6.7903642
6	1.9126271	6.9966622
9	1.9129246	6.9999276
12	1.9129283	6.9999681

How does one know when to stop, if the required cube-root is not already known ? For this purpose, we recall that, whether N is greater than or less than unity, repeated square-roots of the same, approach unity. This is a good indication of the number of steps required to get an accurate value of the cube-root of N. In other words, operations should continue until 1,00000000 is displayed.

Remark

Each step in the above procedure involves pressing the square-root key TWICE. If the key is pressed only ONCE at each step, we get back the given number N. If the key is pressed THRICE at each step, we get the seventh-root of N. If the key is pressed FOUR TIMES at each step, we get the fifteenth-root of N. By cubing the fifteenth-root, we get the fifth-root of N.

A pocket-calculator with a cube-root key, but without the sqaure-root key, is a rarity. With such a calculator, by pressing the cube-root key exactly ONCE at each step, we get the square-root of N.

A calculator with both types of keys is also conceivable. On such a calculator, if each step involves pressing each key exactly ONCE (in any order), we get the fifth-root of N. If each step involves pressing the square-root key ONCE and the cube-root key TWICE (in any order), we get the seventeenth-root of N. If these are interchanged, we get the eleventh-root of N. Many other interesting possibilities can be worked out.

Tiger : The Endangered Species

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OVER THE past century, the combination of land clearing, uncontrolled slaughter, habitat destruction by livestock and disease have drastically reduced India's wildlife population which was one of the world's greatest wildlife population in the nineteenth century. Though the population of wild tiger has been drastically reduced yet India remains the biggest tiger range country in the world with a population of over 3000 tigers to control. A report of environmental conservation organisation states, 'poaching for Chinese medicine has a lucrative market in the West and is responsible for the death of at least one tiger in India every day'. Indian officials feel that these figures are exaggerated. The realstic figure could be one tiger a week. This implies, the tiger, India's pride, is on the brink of extinction and unless urgent actions are taken this majestic animal and its natural habitat will be lost for ever. Although available trade data does not indicate India as a supplier, yet by virtue of the number of tigers here and extent to which hunting appears to be taking place, India could be one of the major countries for the supply of tiger parts and derivatives.

Despite the Wildlife Protection Act, 1972, which extended total legal protection to tigers in India, poaching poses a new threat to the big cat as tigers are killed for skin, bones and other body parts. The tiger is threatened almost exclusively by human action and unless Government takes necessary steps, the efforts of the conservation community can only have a delaying effect on the decline. The tiger's population is dwindling not only in India but throughout the world due to habitat loss and continuance of its illegal poaching to provide the thriving trade of traditional medicine. Tiger body parts are highly prized in centuries-old Chinese traditional medicine, and aficionados readily pay large sums to consume the tonics which are said to cure a host of ailments such as impotence and rheumatism. Approximately 1.15 million hectares of forest's were lost in developmental projects in India from 1952 to 1980. Forest land for non-forest purposes, has failed to check the menace of deforestation. Poaching is one of the prime factors which has endangered the tiger, its habitat and food chain and the tiger cannot be saved unless the ecosystem as a whole is protected. Keeping in mind the severity of the situation, forest department arranged silver jubilee celebrations of 'Project Tiger' in the year 1998, for comprehensive assessment of the big cat and its habitat. The major triumph for tiger conservation in 1998 was the passage of legislation by the US Congress banning import and sale of any product claiming to contain ingredients made of tiger or rhinoceros. This welcome step is going to have a worldwide impact.

At present, the tiger population is estimated to vary between 5000 and 7200 down from an estimated 100,000 in Asia at the turn of the last century. India which believed to have had over 40,000 big cats has now a fewer than 3000. Though the Union Government has not officially released the 1997 tiger census report, Worldwide Fund for Nature (WWF)—Tiger Conservation Programme (TCP) made available the figures provided by 16 State Governments to the Centre with Madhya Pradesh recording a maximum of 927 felines followed by Uttar Pradesh with 475 and Assam listing 458. The 1997 figures for Arunachal Pradesh, Nagaland, Maniupr, Goa and Karnataka are yet to be obtained. The 1993 estimate had shown 3750 tigers in 21 states as compared to 4334 in 1989. The latest 'Tiger Update' of the WWF quoted the census figures, 'as released by State Governments to the Centre' and said that total population of the big cat in reserves as well as outside in 1997 to be 3232 in 16 states. But some officials are of the opinion that this figure has been 'jacked up' to provide inflated figures. As per the 1997 census, tiger reserves excluding the Periyar reserves of Kerala had 1458 tigers against 1333 counted three years ago.

Tiger conservation has been rarely supported by local community living in and around the protected areas. With the declaration of protected areas, restriction were imposed on access and use of resources like fuelwood, fodder, small timber, grazing areas and non-timber forest produce bringing the humans in direct conflict with the animals particularly the tiger, lion or leopard. But to reduce the incidence of tiger-human conflict, the WWF has teamed up with the department and Wildlife Conservation Society to conduct awareness programmes to educate villagers about the reasons tigers prey on livestock and people. These organisations have also begun a 'camera-trapping' exercise using infra-red beams to photograph elusive tigers in their jungle habitat and to monitor their movements. Due to increased deforestation and consequent degeneration of natural resources, the incidence of tigers straying into populated areas have increased. For example, a 20 year old tiger was killed by a bus while crossing a road near Kuala Lumpur, the capital city of Malaysia in November, 1998. Based on an examination of its stomach contents, wildlife officials said that the tiger had not eaten for five days. This has also resulted in tigers attacks on domestic animals, cattles and humans.

Humans are not the natural prey of tigers. It is only when they find difficulty in getting their natural prey like deer or they turn old, crippled and starved they start hunting slow moving beings like humans. Tigers are normally solitary animals and a male tiger needs about 40 square kilometres to mark its own territory to hunt and mate. Tigers normally avoid people, but will strike if startled or confronted

Tigers, except when wounded or when maneaters, are on the whole very good tempered. Occasionally a tiger will object to too close an approach to its cubs or to a kill that it is guarding. The objection invariably takes the form of growling, and if this does not prove effective it is followed by short rushes accompanied by terrifying roars. If these warnings are disregarded, the blame for any injury inflicted rests entirely with the intruder.

To ensure the safety of the national animal, a number of measures are urgently needed and these are under active consideration of the authorities.

- New legislations are required to provide a legal support to the efforts of wildlife conservation officials. At present, action is taken against defaulters trying to smuggle wildlife products under the Customs Act, but once the chapter on Convention on International Trade in Endangered Species (CITES) legislation is incorporated in the Indian Statue, it would be possible to take action under the Wildlife Protection Act itself. As India is a signatory to CITES, the technical mission will be visiting India this year to assess how far India has fulfilled its obligation under the resolution made in 1997. The European Union and the US have CITES legislation on their statute. With the aim of eliminating the trade in tiger parts and derivatives, the 10th CITES Conference in Harare, 1997 urged all parties and non-parties especially the tiger range and consumer States to adopt comprehensive legislation and enforcement controls as a matter of urgency.
- Indian border is very porous specially with countries like Nepal, Bhutan and Myanmar. There is a need to make the Customs and ITBP officials posted on the border of India more aware of the tiger trade. Due to the lack of awareness many a times the trade goes unhindered. For example, there is legal trade in cattle bones and if the tiger bones are mixed with the cattle bones, it can pass, so if the Customs officers are aware 'they will at least look at the consignment.'
- At present maximum penalty under Wildlife Protection Act is merely Rs. 25,000 which is not adequate to deter illegal trade. It should be enhanced and made adequate and deterrent.
- Few more measures are under Government consideration. These include : (i) Enhancing the Ninth Plan allocation for wildlife conservation following proposals for the formation of a 'strike force' in each state with tiger reserves; (ii) Increasing the number of tiger reserves to 25. Three proposals for setting up sanctuaries, one at Bhadra (Karnataka), the second at Mehano (Arunachal Pradesh) and third somewhere in Maharashtra have been received; (iii) Increasing the compensation package to villagers who suffer from tiger attack; and (iv) Counting the head of tigers every year instead of biennially.

Social organisations and scientists are also not lagging behind and doing their best to save this endangered majestic species. For making tiger conservation programmes effective, frequent workshops on 'saving the tiger' have been organised in previous years. Forest Ministers 'wardens' of various states, chief conservators of forests, chief wildlife wardens, field directors of various tiger reserves have participated and exchanged their views in these workshops. Social organisations working on this theme also arranged video shows, painting and slogan competitions and interactive sessions in various parts of India to disseminate the message of preservation of natural ecosystem. To promote safety of the national animal, 'Love the Tiger Walk' was organised in Delhi on 15th February 1999 from the Zoo to the 'Project Tiger' headquarters near India Gate.

Scientists are devising new methods for conducting the survey of endangered animals. In a major breakthrough, Centre for Cellular and Molecular Biology, Hyderabad had developed a new technique for isolation of DNA from scat i.e. faecal matter of tigers and lions. This brilliant innovation will help in making the survey of the big cats without physically touching them and assist in determining their genetic diversity. Scat is an ideal source for collection of DNA non-invasively since it does not involve direct or indirect contact with tiger, DNA is extracted from the large number of epithelial cells present in the scats. This avoids the necessity of tranquillisation of animals for the collection of blood sample, tissue or semen. Animal lovers earlier have been objecting to the tranquillisation of animals. Days are not far when wildlife management will be done through satellite. Scientists from Regional Remote Sensing Service Centre, Kharagpur have recently used the satellite data to trace the wild animals movement in north Bengal. Satellite remote sensing data can be of great help in quick assessment and real time monitoring of existing natural resources and wildlife habitat management.

According to WWF investigations only five sub-species of tiger are left in the world. Tiger is India's pride and every citizen should ensure the safety of the national animal and see that criminals are not able to plunder the country's wildlife. But decline in management standards, increasing incidents of poaching and inadequate budgetary allocations and poor infrastructure are hampering the conservation programmes. Strict measures need to be enforced to ensure that resource allocations for tiger conservation are not siphoned off for other activities. It is felt that this species would have been closer to extinction in the country had it not been for 'Project Tiger'. Twenty-eight years after 'Project Tiger' was launched conservationists now appear hopeful and think that, 'the striped feline no longer faces the threat of extinction, but in some areas the situation is alarming due to rampant poaching and steady loss of habitat'. The tiger population in India has stabilised following a number of measures taken by Government, the WWF and other non Government organisations to save the big cat. However, tigers remaining in wild are still in danger and constant vigil has to be maintained.

Founder of Our Space Programme

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ROCKETS HAVE taken the public imagination by storm in the post-World War II period. The landing of human beings on the moon and the positioning of geocentric communication and weather satellites were but dreams of science fiction writers for a long time. And they would have remained dreams but for the development of powerful rockets.

Great rockets were firmly believed to be the playthings of powerful and advanced Western nations for a long time after World War II. In fact Americans and West Europeans were astounded by even the Soviet Union launching an earth satellite "Sputnik" in October, 1957. Many of them believed that the German scientists captured by the Russians after World War II must have been responsible for the feat ! Such being the case, their opinion of the capability of a developing nation like India can be imagined.

But science and technology are nobody's monopolies. If a nation is determined to progress in a particular field and concentrates its efforts in that direction it is bound to achieve substantial success. So was the case with our space programme too. But a nation does need dedicated and imaginative scientist-administrators to lay the firm foundation necessary for such a grand effort. India found its man for this mission in Dr Vikram Ambalal Sarabhai. He was to our space programme what Homi Bhabha was to our nuclear programme, namely the foundation layer.

Sarabhai was born on 12 August 1919 in Ahmedabad into a wealthy family of industrialists. The family was equally well known for its public spirit, best typified by the educational institutions it founded and ran. An atmosphere of intellectual interests and social consciousness pervaded their home. Naturally, the family attracted political and social leaders like a magnet—Rabindranath Tagore and the philosopher J. Krishnamurthy were among the many luminaries that Sarabhai came to observe and admire at an early age.

After education in the family school (not surprisingly run along the liberal lines of the Montessori system) Vikram Sarabhai joined Gujarat College, Ahmedabad. Later he went over to Cambridge University and in 1939 obtained his Tripos in natural sciences. On the outbreak of the Second World War in September 1939 he returned to India and went to work under Prof. C.V. Raman in the Indian Institute of Science, Bangalore. Cosmic rays was the subject chosen by him.

The deep-space origins of cosmic rays gradually turned Sarabhai's interest towards space exploration. But there was no scope for any work in this field in colonial India. He had to wait for the dawn of our Independence.

In Bangalore, Vikram met and married Mrinalini Swaminathan. True to the family's traditions she was deeply interested in the fine arts and was to gain fame in her own right as a Bharatanatyam dancer. They were blessed with two children, a son Karthikeya and a daughter, Mallika.

With the war over in 1945 Sarabhai resumed his studies in Cambridge, obtaining his Ph.D. degree in 1947 on the topic "Cosmic Ray Investigations in Tropical Latitudes". He returned to India in the same year and started the Physical Research Laboratory in Ahmedabad (the family fortunes were large enough for him to found an institution on his own !). Prof. K.K. Ramanathan, an eminent Meteorologist, was the first director.

Vikram Sarabhai had inherited his family's knack of founding flourishing institutions. With the help of private and governmental funding the Physical Research Laboratory has today become a leading scientific research institution in India. Sarabhai was deeply attached to his brainchild. In later years he would periodically return to this Laboratory and spend some time there to emotionally rejuvenate himself.

Few scientists make good managers, possibly because the temperament required is so different for the two fields. Vikram Sarabhai was an exception to this. He was a brilliant organizer too. He developed the family firm Sarabhai Chemicals to be a leader in this field. He had the born administrator's ability to size up a person's capability and character very quickly. He welcomed foreign collaboration but made sure that he was always in control. His subordinates were allowed great initiative and were never penalized for honest mistakes.

Sarabhai also played an important part in building up the Ahmedabad Textile Industry Research Association (ATIRA) by persuading this essentially family-oriented industry into accepting modern methods of production and management. He was also involved in the establishment of the Indian Institute of Management (IIM) in Ahmedabad, today one of the leading management schools in the country.

Talent, as they say, can not be hidden under a bushel. A man of great ability and drive is easily noticed. Jawaharlal Nehru, the first prime minister of free India decided that Vikram Sarabhai was the man to head India's space effort. Beginning his efforts in 1962, Sarabhai established the rocket research station in Thumba in Kerala, later to be expanded into a full-fledged space research and development centre. In recognition of Sarabhai's role in our space efforts, this centre now bears the name Vikram Sarabhai Space Research Centre. Another establishment came up in Sri Harikota in Andhra, a communication centre in Ahmedabad and so on until today a network of 15 important centres form the organization whose achievements have done the country proud — Indian Space Research Organisation (ISRO).

An administrator of vision is one who can see beyond the immediate problems to the ultimate shape of the institution he is building. Sarabhai's strongest point was his clear and definite vision for India's space programme. He wanted it to serve the country's educational and communication needs and if required function as the base for the country's military rocket programmes. Accordingly he drew up a ten-year plan, consisting of first developing small sounding rockets for weather studies, to be followed by launch vehicles for communication and earth resources satellites. The well-known INSAT series of satellites have fulfilled this objective.

The sudden death of Dr Homi Bhabha in 1966 led to Sarabhai having to take over the Chairmanship of the Atomic Energy Commission also. Sarabhai was helped enormously in his heavy responsibilities by two priceless gifts, the capability to quickly understand the basics of any complicated problem and the ability to choose able subordinates. Once he chose a man he left him free to function and supported him to the hilt. Hence it is no wonder that he was able to command their absolute cooperation and even devotion.

Like his predecessor Dr Bhabha, Sarabahai was a fervent believer in the use of nuclear energy for electric power generation. Under him, the nuclear power stations at Tarapore, Kalpakkam etc. were planned and started. He also functioned as the Chairman of the Electronics Committee and helped lay the foundations of that industry in this country.

His family background made Sarabhai take a keen interest in a wide range of fields, many unconnected with his own, but vital to society's well-being. He applied his mind to problems plaguing our agriculture, transportation, minerals extraction etc. He took pains to set down his opinions on these subjects on paper and send them to those in a position to take decisions. He felt that it was his duty to put his talents to the service of the nation in all possible ways.

By his achievements Sarabhai won the gratitude of the nation. He was awarded the Bhatnagar Memorial Award for Physics in 1962, Padma Bhushan in 1966 and posthumously Padma Vibhushan in 1972.

Sarabhai was given to working incredibly hard. It seems as if he had a premonition of the very short time granted to him on this earth and wanted to make the best use of it for his country. But whatever the reason, Sarabhai suddenly passed away due to cardiac arrest on 30 December 1971. With his background he could have passed a life of leisure but instead strained himself to the limit in the service of his nation. We all have reason to respect his memory as the Founder of Indian Space Programme.

Teaching Values through Mathematical Logic

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ONE OF THE main tasks of mathematical logic is the investigation of formal thinking and inference by means of mathematical methods. The word logic according to Collin's dictionary means science of 'reasoning'. It is basically a process which investigates the assertions of statements in order to arrive at a conclusion with the use of laws of logic. It comprises multitude of applications to the most diverse domains such as the natural sciences, switch work algebra, the theory of data processing systems, linguistics, philosophy, laws and ethics. In our traditional system of education 'Science of logic' *(Tarak Sastra)* was an important area of the philosophy to be taught and learned by the students and it was used by philosophers in the debates. Now-a-days it has gained more prominence than merely using in debates because of the advent of computer technology. That is why in the revised syllabus guidelines mathematical logic has been introduced as one of the frontline areas in the school curriculum by the NCERT. Since curriculum to a large extent is shaped by the culture of society in which it operates the transaction of mathematics curriculum contributes towards development of society's political, ideological and cultural maintenance besides the technological and socio-economic development. Its contribution to the development of general mental discipline and capacity, in particular 'reasoning power' is seen as the justification for occupying special place in the school curriculum and an important reason for providing substantial mathematics education to large segments of the population.

Perceiving the social role of mathematics education, the curriculum transaction should aim at imparting those forms of knowledge, the skills, values and attitudes that not only motivate and control conduct but enable students to discriminate between right and wrong and true and false in all the situations of everyday life. Mathematical logic can be one of such areas that practising teacher may use to inculcate habits commensurate with value education. For example, while discussing concepts/subconcepts of mathematical logic illustrations may be cited that highlight social and moral values like responsibility, fairness, respect, citizenship, trustworthiness, honesty, attitude of caring, concern about environment, contentment etc. Let us illustrate some examples using three connectives namely conjunction, disjunction and negation.

In the context of logic a statement is a sentence or verbal assertion conveying a situation which is neither imperative, interrogative nor exclamatory. The fundamental property of the statement is that it is either true or false but not both. The truthfulness or falsity of a statement is known as its truth-value. Composite statements are composed of substatements and various connectives namely 'and', 'or', 'not', 'if then', 'if and only if'. The fundamental property of composite statements is that its truth value is completely determined by the truth value of each of its substatements. The teacher may cite the following examples while making truth tables for conjunction, disjunction and negation.

Example 1 : Be accountable for your action and think about the consequence of your behaviour before your act.

This is a composite statement with substatements 'Be accountable for your action' and 'think about the consequence of your behaviour before you act'.

It imparts responsibility value.

Example 2 : 'Do not take credit for other's work'.

This is not a statement, since it is neither true nor false but an imperative one.

Example 3 : Contentment gives real joy of life or discontentment gives lust for wealth.

This is a composite statement with substatements 'contentment gives real joy of life' or 'discontentment gives lust for wealth'. Let us elaborate these values using the connectives as follows :

Conjunction : $p \wedge q$

Any two statements say p and q can be combined by the word 'and ' to form a composite statement which is the conjunction of the original statements. Symbolically, the conjunction of two statements (p and q) is commonly written as $p \wedge q$.

The truth value of $p \wedge q$ is obtained if both p and q are true otherwise $p \wedge q$ is false.

Example 4 : Consider the following four statements :

(1) Fairness comes when we treat all people fairly 'and' listen to oppositing point of view.

(2) Trustworthiness comes by being honest 'and' 2 + 2 = 5.

(3) Betraying a trust leads to trustworthiness 'and' 2 + 2 = 4.

(4) Wealth is bad when earned by right conduct 'and' right behaviour.

The truth table of these statements is :

Truth Table 1

Statements	*p*	*q*	*$p \wedge q$*
(1)	T	T	T
(2)	T	F	F
(3)	F	T	F
(4)	F	F	F

These examples provides an ample opportunity to discuss the values like 'fairness', 'trustworthiness' ... in the class.

Disjunction : $p \vee q$

Any two statements combined by 'or' to form a new statement leads to disjunction which is symbolically written as $p \vee p$. Its truth value is obtained if p is true or q is true or both p and q are true.

then p ∨ q is true otherwise p ∨ q is false. Let us consider the following statements to obtain the truth table.

(1) Contentment gives real joy of life 'or' courtesy brings respect.

(2) Contentment gives real joy of life 'or √2 is a rational number.

(3) Application brings disrespect 'or' 3 + 5 = 8.

(4) Taking credit for other's work brings respect 'or' 2 + 3 = 4

Truth Table 2

Statements	p	q	$p \vee q$
(1)	T	T	T
(2)	T	F	T
(3)	F	T	T
(4)	F	F	F

The teacher can elaborate on these values and prepare a number of truth tables.

Negation, ~P

Given any statement p, another statement can be formed by writing negation of p. Symbolically, the negation of p is written as ~p. Consider the statements:

Example 1 :

(1) Education leads to successful life.

(2) Education does not lead to successful life.

(3) It is false that education leads to successful life.

Statements (2) and (3) are each negation of (1).

Example 2 : We should develop an attitude of caring and sharing.

(2a) : We should not develop an attitude of caring and sharing.

(2a) is the negation of (2). Similarly we can have various types of value based examples which will help young to discover the good and learn to become individuals of character.

Conway Dorselt recently suggested that a good curriculum respects and balances the need to educate the 'three people' in each individual : the worker, the citizen and the private person. Schools can/need to take a stronger role in helping young to discover a person of character in themselves. To achieve this we have to ensure that value based approach becomes backbone of our educational system.

Cognition of Learning Chemistry

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EDUCATION HAS two components, teaching and learning. Much of the art of teaching centres around the learning experiences that are provided to the learner. The implications of the promise of producing a learner-centred environment lie in understanding the importance of individual differences in learning styles (J.J. Logowiski). The promise of educational psychology and the cognitive sciences, allow teachers to treat students as individuals with varied backgrounds, attitudes and needs. This arouses the urge to re-look at the current system, which for the most part, is driven by a mass production philosophy. Thus, the signal for the teacher is very clear and that is, "that it is difficult to treat students as individuals if they are not seen as individuals". In the present article an attempt has been made to highlight, how students can be engaged in meaningful learning in chemistry especially at the +2 stage. My long experience of imparting instruction in chemistry has strengthened the belief in me that to make an individual effective student, the following five areas are very vital. These are :

(i) Organisation of knowledge.
(ii) Faith in application of knowledge acquired.
(iii) Association in different walks of knowledge.
(iv) Metacognition promoting individualized system of learning.
(v) Cognitive conflict as a strategy for meaningful learning.

It may at this stage now be worthwhile to explore the latent potential in each of these areas for the pursuit of knowledge.

Organization of Knowledge

Organization of knowledge at once brings into focus the Ausubel's Advance Organizer Model of teaching. Here the psychologist opines that knowledge if imparted in piecemeals does not create any impact on the learner, instead if it is imparted within the gamut of some Principal Ideas (Organizers) which may come in advance to the specific knowledge being imparted, may create better impact on the learner. Learner psychologically feels as an effective contributor because the quest for new knowledge is the hallmark of the model. The following few ideas would help to illustrate the above view point.

Chemical bonding is highly central to many ideas of teaching chemistry and the first experience that the learner encounters perhaps is in the form of 'Ionic Bond'. Here too, the usual example is the following reaction.

$$Na(s) + \frac{1}{2}Cl_2(g) \longrightarrow (Na^+Cl^-)x$$

From the point of view of learning experience, the only experience here is the assimilation of the fact by the learner: that in sodium chloride, the bond between sodium ion and chloride ion is ionic bond. However, if the teacher introduces the following organizer, "Metals with low ionization energy whenever interact with non-metals of high electron affinity, the bond usually formed is the ionic bond and the extent of ionic character of the bond depends on the nature of interacting species", this definitely would place the learner in a beneficiary situation. Learner would now be inclined to probe and prepare an exhaustive list of the metals with low ionization energy and non-metals with high electron affinity to judge the implication of this statement. Doing so may even inspire the learner to bring home the replacement of the above reaction by the following reaction :

$$M(s)^{+} \tfrac{1}{2} \times 2\ (s,\ l,\ g) \longrightarrow (M^{+}X^{-})_{x}$$

which further suggests that this single reaction emcompasses twenty examples of the process of ionic bond formation with respect to the alkali metals and halogens (excluding radioactive Franciumm and radioactive Astatine). Once thinking of this sort is initiated then the student's own thought process may encourage him/her to search for answers the following questions.

(i) Which metals other than alkali metals respond to the process of ionic bond formation ?

(ii) Which non-metals other than halogens may also cause the change being contemplated ?

(iii) Can it be possible that a metal with comparatively high ionization energy interacts with non-metals of low electron affinity to form an ionic bond ? (Recall that amongst the alkali metals only Lithium combines with Nitrogen to form ionic compound).

(iv) How is the extent to ionic bonding related to the size of the cation and the size of the anion ?

(v) Is the shape of resulting solid also dependent on the size of the ionic species ?

(vi) Is the solubility of the resulting solids also dependent on the bonding pattern of the solid ?

(vii) Are melting temperature of solids dependent on their structure ?

The purpose of introducing the organizer in advance to the learning ideas is to set the process of inquiry in the mind of the learner to build up right attitude towards the process of learning.

The idea being transacted may further be strengthened with another illustration. Cell reactions are an important part of chemistry curriculum at +2 stage. Before teaching electrolytic and electrochemical cell reaction, if the teacher introduces the following idea in advance namely :

"Changes are spontaneous as well as non-spontaneous, electrolysis is a nonspontaneous redox change; occuring at the expense of electrical energy", this will then put the learner in a highly advantageous situation, as this organizer would encompass in it several learning situations, prominent among these are :

(i) The thermodynamic consideration for the spontaneity and non-spontaneity of the reactions.

(ii) Correlating radioactivity with organizer (recall that natural radioactivity is a spontaneous change whereas artifical radioactivity and transmutation of elements is a non-spontaneous process).

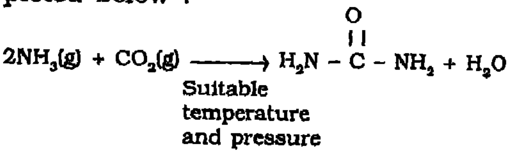
(iii) Faraday's Laws, which are highly central to the phenomenon of electrolysis, derive inspiration from non-spontaneous changes.

(iv) Electrochemical cell reactions are spontaneous changes as the cell reaction has a driving force in the name of cell potential available from the cell designed.

(v) Electrolysis too is a type of redox change inviting oxidation at anode and reduction at cathode.

Faith in Application of Knowledge Acquired

The zeal for learning is created only, provided the learner appreciates that this is closely related with his/her immediate environment. The urge for the interest in Van der Walls' interaction would only be created, if one correlates that the principle of liquefaction of gases can be made applicable to air also and the liquefaction of air is important issue for us as nitrogen is the chief source of liquid air. It is this nitrogen, that is utilized to manufacture ammonia. Ammonia is the base material used in the fertilizer industry to manufacture nitrogenous fertilizers. The well known fertilizer urea is obtained by the action of carbon dioxide on ammonia as depicted below :



$$2NH_3(g) + CO_2(g) \xrightarrow[\text{Suitable temperature and pressure}]{} H_2N - \overset{\overset{O}{||}}{C} - NH_2 + H_2O$$

Urea is highly soluble in water, which is easily assimilated by the soil and through the soil, nitrogen if the urea is fed to the plants for their growth as it is one of the macronutrients for them. It is with this knowledge the learner may get the temptation of knowing several issues connected with the manufacture of urea such as :

(i) Air is a mixture of several gases; is the pattern of intermolecular attractions the same as in the case of pure gas or different from that?

(ii) How is nitrogen separated from liquid air ?

(iii) What is the efficacy of converting nitrogen into ammonia.

(iv) How do we get carbon dioxide needed for this purpose ?

(v) What are those industrial processes, which generate carbon dioxide as their by-product ?

(vi) Why is urea soluble in water ?

(vii) What other nitrogenous fertilizers can be manufactured from nitrogen ?

(viii) Among the various nitrogenous fertilizers, which one imparts nitrogen to the plants with greatest efficacy ?

Similarly, sodium chloride, which is a very important component of our diet and other life activities, is mainly extracted from sea water. The right urge to learn about its process of extraction can only be created if the scope of the chemical issues connected with sodium chloride is broadened. Some of the vital issues that are connected with the chemistry of sodium chloride are :

(i) How does a sample of commercial sodium chloride differ in behaviour from a sample of pure sodium chloride ?

(ii) How is pure sodium chloride obtained from commercial sodium chloride ?

(iii) Why is a commercial sample of sodium chloride hygroscopic in nature ?

(iv) What other important chemicals can be obtained from sodium chloride ?

(v) Is it possible to prepare chlorine on a large scale without using sodium chloride ?

(vi) Which other important inorganic chemical products are manufactured from chlorine ?

(vii) How is chlorine linked with a variety of organic products ?

The concept of electrode potential and the idea of redox processes are the two ideal illustrations to facilitate development of faith in the application of knowledge acquired as these are intimately linked to the metallurgical extractions, electro-preparation of lot many materials as also to the existence of dry cells, chargeable batteries and the emergence of fuel cells.

Association in Different Walks of Knowledge

To become an effective learner, one should always explore the possibilities of associating the knowledge being imparted, with the other frontiers of knowledge. The following activity may illustrate this idea.

Drop a piece of sodium (about 0.5g) in a hard glass test tube containing about 20 ml methanol. What happens? You may place on record that evolution of hydrogen is seen on account of the following reaction.

$$Na(s) + CH_3OH(l) \longrightarrow CH_3ONa\ (solution) + \tfrac{1}{2}H_2(g)$$

A careful glance at the reaction may bring into focus several points, prominent among these are :

(i) Is this a redox change ?

(ii) If it is a redox change, who is oxidised and who is reduced ?

(iii) What type of bonding is present in the compound sodium methoxide?

(iv) What is the utility of the compound sodium methoxide ?

(v) Are solvent molecules also attached with Na^+ and CH_3O^- ions in solution ?

(vi) Do other alcohols also show this reaction ?

(vii) What is the ease of this reaction when the alkyl group mass increases for the different primary alcohols ?

(viii) What is the ease of reaction with alcohols differing in nature with carbon being labelled as primary, secondary and tertiary ?

(ix) Can this reaction be also called as acid-base reaction ?

(x) What other solvents can cause this reaction ?

(xi) Would the similar type of reaction occur with other alkali metals ?

(xii) Why can alkali metals be stored safely in solvents like kerosene, benzene etc. ?

(xiii) What would be the ease of occurrence of the reaction if alcohols are replaced with corresponding thioalcohols ?

(xiv) CH_3O^-, OH^-, H^-, and NH_2^- are bases. What is the relative tendency of these species to act as bases ?

(xv) What are. the pKa values of H_2O, CH_3OH C_2H_5OH ?

(xvi) Do alkali metals always act as reductants in their reactions ?

Thus the meaningful learning would occur only if the search for correlating the knowledge acquired with new ideas becomes a never ending process in itself. After all only discovering remote association between different ideas leads to creative ideas.

Metacognition for Individualised System of Learning

The development of instructional methods that would improve the conceptual understanding and problem solving abilities of students in science classes has long been a goal of science instructors and science education researches. Because promoting thinking about ones own thinking (metacognition) in the classroom seems like a promising way to achieve these goals, some science instructors have begun to implement instructional methods intended to encourage students to be more metacognitive. In introductory science courses, these efforts focus on making students more aware of their own ideas, and include the use of such instructional tools as concept maps, concept tests, Predict Observe-Explain (POE) tasks and the Model-Observe-Reflect-Explain (MORE) thinking frame. Efforts to promote metacognition in chemistry courses have been focused on making students aware of the ideas through the use of concept maps [Stensvold, M; Wilson, J.J. (1992), Nakhleh, M.B. (1994), Regis, A. et.al. (1996), Francisco, J.S. et.al. (1998)]. Concept mapping which was developed by Novak and Gowin (1984) involves the construction of a diagram that emphasises relationship between concepts.

The concept tests is another metacognitively focused instructional tool that many chemistry instructors have recently adopted. Concept tests are multiple-choice questions carefully constructed to expose students, ideas that are at odds with scientifically accepted views. Students are presented with a question during a lecture and asked to vote on the answer. After this initial vote, students are allowed time to discuss the question with others around them before a final view is made about the answer. Significant change in the perception is highlighted. The concept test ends with the instructor's explanation of his or her thinking about the question. The activity structure ("Peer instruction") used in the Concept Test was developed by physicist Eric Mazur for his lecture at Harvard University. Mazur was found that lectures taught using peer instruction improve students' conceptual understanding and problem solving in machines [Mazur. E (1997)]. Thus far, no studies of the instructional effectiveness of using Concept Tests during chemistry lectures have been published.

In Predict-Observe-Explain (POE) students make predictions about an event and explain the reasons for their predictions, thus highlighting their initial thinking. Then they observe a demonstration or conduct a laboratory experiment and are required to reconcile their observations with their predictions; this intended to cause students re-examine their initial ideas. To give more credence to POE, rather than the inidividual group of students are asked to pool their data and try to agree on a common set of observations.

The Model-Observe-Reflect-Explain (MORE) thinking frame intended to get at the goals by providing students with a framework to guide their thinking. This frame includes the idea of refinement. Thus, after each experiment in a module, students are explicitly prompted to reflect upon the implications of their observations for their model and revise their ideas accordingly. Students in this MORE thinking frame are found to develop enhanced metacognitive abilities to solve examination problem through enhanced understanding of chemical ideas.

Metacognition is undoubtedly an indispensable aspect of chemist's 'thinking and students' learning about chemistry. Yet, perhaps, owing to lack of awareness of the importance of metacognition, or alternatively, the belief that it is not the responsibility of science instructors to foster metacognition abilities, little research related to the role of metacognition in learning of chemistry has been done.

Cognitive Conflict as a Strategy for Meaningful Learning

Cognitive conflict has been recognised as a powerful strategy for learning because here the quest for learning is created. Cognitive conflict can be experienced in the following ways :

(A) Surprise Produced by a Result that Contradicts the Expectation of the Learner

In chemistry, there are several situations that can be cited, few of these are:

(i) When we introduce the data of electron affinity, the expectation of the learner is that it is a periodic property and that this decreases down the group, but the learner stands baffled, when he/she finds that the electron affinity of fluorne is less than that of chlorine. To count for the given data, the learner has to go in search of a convincing explanation which in turn enriches learners' experiences.

(ii) Though electrode potential concept suggests that pure zinc should react with dilute hydrochloric acid to produce hydrogen, yet in reality this is not encountered. An additional concept in the name of overvoltage has to be introduced to satisfy the learner.

(iii) Phenol turns blue litmus solution red and is also said to be CARBOLIC ACID, yet it does not produce any effervescence with $NaHCO_3$, whereas all carboxylic acids do so. Tri-nitro derivative of phenol, picric acid (2, 4, 6 trinitro phenol) does produce effervescence with $NaHCO_3$. The idea of comparativeness of acidic strength and electronic influence of the substituted group in benzene groups has to be taken into consideration to count for the observed behaviour.

(iv) Solubility is a property that does not follow any rule, for example AgF is soluble in water, whereas AgCl, AgBr and AgI are no soluble. Whereas CaF_2 is insoluble in water, $CaCl_2$, $CaBr_2$ and CaI_2 are soluble. This situation would encourage the learner to appreciate the conclusion that solubility tends to strike the balance between solvation energy and crystal energy.

(v) Though species like I_3^-, N_3^-, $S_4O_6^{2-}$, Fe_3O_4, Br_3O_8 etc, experience fractional oxidation state of the element. Yet this picture is not a reality. The learner has to go back to the structural parameters and the basic assumptions of the idea of oxidation state to resolve this issue.

(B) Learner Experiences a Feeling of Puzzlement Leading to Uneasiness

Here a sort of academic tension is created in the learner and he/she feels relieved only if the right solution to the problem is experienced. The following episodes highlight it :

(i) For formic acid, its equivalent mass is equal to its molecular mass when it acts as an acid but when it acts as a reducing agent then its equivalent mass is one half of its molecular mass [The more meaningful outcome experienced by the learner is that equivalent mass of the substance depends on the mode of change in question].

(ii) H_3PO_2, H_3PO_3 and H_3PO_4 are the oxo-acids of phosphorous wherein each molecule contains three hydrogen atoms yet these acids differ in their basicity. Structural parameter again is a central point to throw light on the issue in debate.

(iii) H_3BO_3 is neither a Arrhenius acid nor a Lowry Bronsted acid, it is a Lewis acid with maximum protocity being unity. This time inability of H_3BO_3 to ionize and ultimately interacting with water to a limited extent, as given below, would find mention.

$(HO)_3B + OH_2 \longrightarrow (OH)_4B^- + H^+$

(iv) Optical isomerism can be shown by alkenes also. Thus, removing the condition of chirality from the knowledge domain of the learner.

(v) Addition of HgI_2 to an aqueous solution of potassium iodide would bring increase in the vapour pressure of the solvent. Thus placing a challenge before the learner to conclude logically that number of moles of particles in the process of addition of HgI_2 to KI solution are lowered, which consequently bring increase in the vapour pressure as compared to the previous situation.

(C) Encountering Situations that Promote Intellectual Curiosity

Few such situations are :

(i) While performing $KMnO_4$ titrations, why do we make the media acidic by adding only dilute sulphuric acid and why can't we add either nitric acid or dilute hydrochloric acid.

(ii) Is the reaction :

$$(CN)_2 + 2OH^- \longrightarrow CN^- + CNO^- + H_2O,$$ like

$$Cl_2 + 2OH^- \longrightarrow Cl^- + ClO^- + H_2O$$

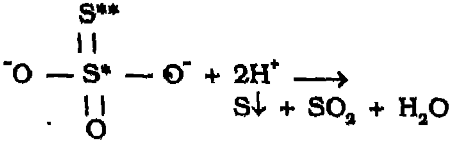
is a disproportion of cynogen?

(iii) In the reaction :

$$ICl + 2OH^- \longrightarrow Cl^- + IO^- + H_2O$$

are the products and why not $ClO^- + I^- + H_2O$ are the products of the reaction ?

(iv) If for the reaction

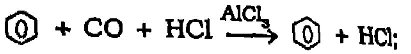


$$^-O - \overset{\overset{\displaystyle S^{**}}{\|}}{\underset{\underset{\displaystyle O}{\|}}{S^*}} - O^- + 2H^+ \longrightarrow S\downarrow + SO_2 + H_2O$$

if two sulphurs are labelled as depicted here, then which sulphur precipitates as elemental sulphur and why ?

(v) Why in the species $^-I \rightarrow I - I$, all the iodines are said to be bonded differently ?

(vi) In the reaction,



what actually is the rŏle of HCl ?

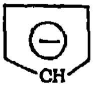
(vii) Why is the reaction of photosynthesis represented as

$$6CO_2 + 12H_2O \longrightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$$

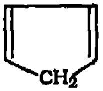
and not as

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2?$$

(viii) Why is the species



said to be aromatic in nature whereas



is not ?

(ix) Why do complex species $Fe(CN)_6^{3-}$ and $[Fe(H_2O)_6]^{3+}$ differ in terms of their magnetic behaviour ?

(x) Why BrO_3^- amongst all the haloates is the strongest oxidant ?

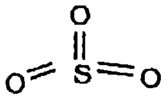
(D) Experiencing a Cognitive Gap

This is encountered when a person concerned is vaguely aware about a learning situation and something is missing from his/her structure of the knowledge. The following few illustrations would reflect upon the idea being discussed.

(i) If aromaticity is defined as systems responding to $(4n + 2)\pi$ electrons, where n denotes number of rings, then it would not be possible to justify how are furan, pyrrole thiophene and several other hetero cyclic compounds are aromatic in their behaviour. However, if aromaticity may be defined as systems associated with (4n+2) delocalized number of electrons, then it would encompass both, the homocyclic as well as heterocyclic aromatic compounds.

(ii) The idea that $MgCl_2$, $CaCl_2$, $SrCl_2$ and $BaCl_2$ differ in their extent of ionic character of the bond can never be comprehended by the students until or unless the cognitive structure is strengthened to introduce the idea of polarization of the anionic cloud by the cation, as it depends upon the physique of the cation, is not strengthened.

(iii) In the molecule of SO_3, whose bonding picture is :



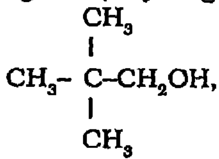
the concept of resonance in the molecule can never be logically established till the introduction of pπ – pπ and pπ– dπ mode of π bonding is not a part of the cognitive structure of learner.

(E) The Learner Experiences Lacunae that arises when the Learner Attempts to Apply his Scheme to a Given Situation

Some such situations are :

(i) Substances like BeF_2, BF_3 are Lewis acids but substances like SiF_4, $SnCl_4$ also act as Lewis acids (Scheme of octet needs a relook).

(ii) Though no β hydrogen is present in

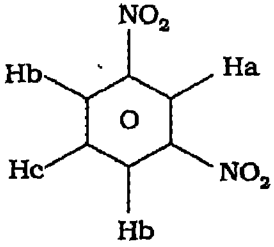


$$CH_3-\overset{\overset{\Large CH_3}{|}}{\underset{\underset{\Large CH_3}{|}}{C}}-CH_2OH,$$

yet repentanol forms alkene on dehydration in the presence of concentrated sulphuric acid (The idea of methyl shift has to be introduced to justify the observed behaviour).

(iii) Substances like PF_5, AsF_5, SF_6, TeF_6, SeF_6 and the like show violation from octet rule. [The idea of enhancement of covalency and expansion of valence shell needs to be introduced to justify the observed pattern.]

(iv) In the molecule :



the hydrogen labelled as Ha, Hb and Hc are different, can't be justified till we introduce the concept of PMR (Proton Magnetic Resonance).

To conclude, it may be placed on record that the purpose of the article is to impress upon the teachers to have faith in the saying that 'Teaching is not filling a bucket but it is lighting a lamp'. If we wish to create interest for teaching then we have to create situations that present challenging tasks for the learners, as it is the knowledge acquired through one's own experiences that has an everlasting impact.

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A Case Study of Physics Learning Difficulties

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A PHONE CALL to me from my grand-daughter, "Physics is confusing. It is stupid to learn physics. During the last week, my teacher taught potential, potential difference, and volt. I am sick of chemistry too. Here we have redox reactions, electrode potential. Please help me to understand these hallow terms." I invited her to come — "I shall try to understand your learning difficulties and clear them out of your path of learning." She is Class IX student.

Meanwhile my own memory went back to the year 1947 when I was in Class X. I recalled my own difficulties. I did learn these words only textually and no more. Whenever the teacher asked me to define potential, I would repeat the text faithfully. I was over-awed by the teacher. The textbook was the only support for me. The teacher was happy because my answer had been correct. I was happy too, but I never understood these words. I never had questions for the teacher. Today's student is really bold but outside the classroom.

My memory flashed across another notable event which happened during my teaching career at the Government College, Chandigarh. That was mid-sixties. One of the students was bold enough to put a question about the concept of potential in the class. "What is infinity, Sir ? Is it one km or 10 km?" Perhaps a bit naughty question. He was a good student. Any senior teacher would perhaps consider it a silly question. But I believed it to be a genuine question. I said it was a naughty question. The reason is that it caused laughter in the class. Perhaps to break the monotony in teaching science. Better still an expression for the sake of interaction.

My grand-daughter arrived with a bagful of questions. She started reading a statement from her textbook. That was the statement read out by her teacher in the class — 'Potential is the amount of work done in moving a unit positive charge from infinity to a point.' And then was the turn of the volley of sulking questions :

1. If potential means work done, then why the new word potential ?
2. What is infinity ? The Sun is at the infinite distance. Do we carry charge from the Sun to the point ? Isn't it funny?
3. What do you mean by high potential and low potential ? When two such points are connected by a wire, current begins to move. But potential means work and current means flow of charge per second. Isn't it snafu (Situation Normal All Fouled Up) ? Why don't we say that work begins to flow ?

4. **The SI unit of potential is volt whereas that of work is joule. Why two different units for work done ?**

Physics is all humbug.. japan jargon (a black varnish which covers the meaning of words), scaring, making my head aching, breaking my peace of mind and staking my honour to understand subtle differences you sometimes give to the meaning of physics words.

I attempted to analyse these questions. I wanted to locate the root cause of these difficulties. I looked at the statement of the potential. I found that the phrase 'electric field due to a positive charge on the object' is missing in the statement. I began my work of clearing the doubts.

G : What is the electric field due to a positively charged particle ?

K : The electric field is in the space where the influence of the charge exists.

G : How can you check the influence ?

K : A test charge when placed at a point in the field is pushed away ?

G : OK. The test charge is pushed away. Why is it pushed away ?

K : A force acts on the test charge and causes a motion in it.

G : How ?

K : We know the test charge is a small positive charge. And the charge on the object is also positive. Like charges repel each other.

G : Fine. So it is clear that electric field exists whereever the test charge is acted upon by the electric force, due to the charge on the object. Can you locate the point where this electric force cannot move the test charge ?

K : Yes.

G : Where would it be ? Note that it depends on the quantity of charge on the object due to which the electric field is generated.

K : It could be a few cm or even a metre.

G : Yes, very right. That point is taken as infinity. Naturally, the infinity is different for different situations. Thus it is a reference point only.

Now the test charge is moved from this point to any other point in the field. You have to do work against the force of repulsion. Force acts in a direction opposite to that of the displacement of the test charge. This gives rise to work done. And this is the energy which we expend on the test charge to bring it to any point in the electric field. This energy is called potential at that point of the field. In language, potential means having strength i.e. powerful. You can say that work done to reach that point is stored in the field at that point. We can recover this energy from that point i.e. it has the ability to do work.

K : The other day you told — If I were to carry my school bag weighing 10 kg from school to home on foot, I did no work ! How come, when test charge is moved from infinity to a point in the field, work is done ? I hold a test charge is one hand and a charged glass rod in the other hand. No work should be done when I move the test charge towards the glass rod. This is all confusion, perplexing. You confute your own argument.

G : You know that work is done when the body moves in the same direction of applied force. The electric force has the direction opposite to that of the displacement of the test charge. Hence the work is done. But when you are carrying a bag, the weight of the bag is acting downwards while you are moving in the horizontal direction. So no work is done in this case.

K : OK. You say that work is done on the unit charge. The energy at that point is called potential. Can't the term 'energy' be used for potential ? Why do we have another word for it ?

G : No. We need to define another term for clarity of the concept 'potential'. Here the work is done in moving a unit charge. And the work done is different from that in moving an object. The former is an electric force and the latter is gravitational.

K : Isn't the property of force to cause motion ? It may be an object or charge. So what if one is electric force and other gravitational ?

G : Yes, you are very right. Here we consider the motion of unit charge in the electric field due to another charged object. The object does not move. It only generates field. Hence the potential has a different meaning. We never consider the motion of unit mass of an object while finding work done on the object. (But note that the mass of earth can have gravitational field and then we can consider unit mass to find out gravitational potential of earth at different points in the space around the earth where the force of gravity acts.) Note carefully the work done is the product of force and the distance moved in the direction of force. In electric field we do work in moving unit charge i.e. one coulomb from infinity to any point in the electric field due to charge on another object. So the potential means the energy i.e. work done per unit charge . That is why we have a new term i.e. potential. It makes it simpler to understand the behaviour of a charged object on other charges in its field.

K : Do you mean that work done is stored in the electric field at that point?

G : Yes, exactly. So high potential means that point is associated with large energy or work done per coulomb. So low potential means that low energy exists at that point. This gives rise to potential difference between two points. Let us take an example. Say, the point A has potential of 60 J/C and point B has potential of 50 J/C. Clearly, A has high potential and B has low potential. When A is connected to B, the current begins to flow so that A and B has the same potential i.e. (60 + 50) × ½ = 55 J/C. When charge flows from A to B, work is done. In other words, A loses some energy (5 J) and B gains that much energy. This is true because the sum total of energy in an isolated system is always conserved.

K : So, it is the energy which flows and not the charge. Why should we say that current flows ?

G : As current flows means charge flows per second, the work is done on the unit charge flowing. Let us look at the problem in a slightly different way. Suppose A has +70 C charge and B has +40 C charge. When A is joined to B by a wire A loses +15 C of charge and B gains that much charge so that they have equal charges i.e. (70 + 50) × ½ = 55 C. Again the sum of the charges on an isolated system is always conserved. Further, we note that A has high potential and B has low potential. Hence the current flows from A to B. Whenever the charge flows, work is done. For simplicity of the ideas we need a different term i.e. potential.

K : Suppose A has -70 C and B has -50 C charges. Will the charge flow ?

G : Yes. Can you tell which of A or B has high potential ?

K : The point A.

G : No it has low potential.

K : That can't be. A has greater number than B.

G : The minus sign indicates that A is more negative than B. In other words, A has less potential than B or B has higher potential than that of A. That is why current flows from B to A. B has more ability to lose charge than A has. The charge of A increases to -60 C and that of B decreases to -60 C. They attain equal charges, since the sum of charges is conserved as before. Isn't it interesting ?

K : It is funny arithmetic. It is all in imagination. Suppose A has +70 C and B has -50 C. A has high potential and B has low potential. Once joined, the charge from A flows to B to make it equal on both points. [+70+(-50)] = ½ × 20C = 10C. Each will have + 10 C.

K : OK. What is the difference between unit of work i.e. joule and that of potential i.e. volt ? Since potential means work done, why do we have need the volt ?

G : We know that work is defined as the product of force and the distance moved in the direction of force applied on the body. The body has no charge. Since unit (test) charge is moved in the electric field due to a charged body, work is done in moving the test charge. When two units of charges are moved work done is doubled. For convenience, we find out work done per unit charge. When work done is one joule for moving one coulomb of charge, the unit is represented as J/C in SI units. In order to honour Volta, for his contributions to the study of electricity, we name this unit as volt, with a symbol, V. 1 J/C = 1 V.

We have discussed some learning difficulties of a physics student. Each difficult word is a great hurdle for further understanding of any physics idea. We have to transact any physical concept with transparent comprehension to the students. Only then an idea finds its application in learning about the events of nature. So it is the way the physics ideas are given to the students which is important in teaching because the student is then urged to self-learning and self-reading. This leads to healthy development of mind. It improves the relation between the teacher and the student. The teaching style of each teacher is unique depending upon his abilities to sense the difficulties of his students. As far as I know, little research work is done in India on these issues. I think the senior teachers do not consider it an issue at all.

I have another event in my teaching career in support of this observation. During seventies I was promoted and transferred to the State Institute of

Science Education (SISE), Punjab for teaching physics to senior secondary school science teachers. The purpose was to upgrade the physics knowledge of the teachers to help them to cope with the difficulties of new physics syllabus. I had a class of about 30 science teachers. They had degrees or even post graduate degrees in science and/or education. One teacher said : "You are an M.Sc., many of us are M.Scs; you are B.T., many of us are BEd/MEds. So what ? What will you teach us ?" It was a serious threat to my teaching career. I mused over the problem for a while. Since I was incharge of the in-service teacher training programme for implementing the Science Education Programme in Punjab, I had to find the way out. I said, "Well, I have to discuss with you some problems of physics education. Nothing to teach but only to learn about the problems mutually.

I posed a simple question. How do you define potential at a point to students of Class XI ? I picked about 12 science teachers who gave the definition of the word potential. And I kept my cool. Each one gave a textbook definition as might be given by them in the classroom. Then I discussed different aspects of the word potential as narrated in dialogues given above. The teachers were really amazed at the simplicity and the beauty of the word potential. It is likely to help students to solve the numerical problems very easily. Many teachers remarked about this fact after the class was over.

These difficulties are precursory to other ideas connected with potential. For example, electrode potential (which is important for predicting chemical reactions), redox reactions, electromotive force associated with sources of current, ionisation potential, contact potential difference, potential barrier (nuclear physics) etc.

I conclude that physics is important but far more important is how physics is passed on to younger generation. We have to shed off our mindset conditioned by our own teachers and repeated text description innumerable times during our teaching without any reflection on our methods of teaching. We have to come down to the level of the conception, perception, understanding, language and needs of the students. The student is the end consumer of our physics ideas. We must analyse the students' reactions and formulate a plan of teaching physics with a view to generating confidence and joy of learning physics among students. However big books may be, I mean self-explanatory, they cannot replace the class teacher. The teacher has emotions whereas the textbook has none.

Science News

Giant Leap for Indian Space Programme

With the successful launching of its first Geo-stationary Launch Vehicle (GSLV) India joined the select club of six nations in the world that have developed this capability. The 'First Developmental Test Flight' of Geosynchronous Satellite Launch Vehicle (GSLV-D1) carrying an experimental satellite, weighing 1540 kg, was launched into space from the Sri Harikota launch station in Andhra Pradesh on 10 April 2001.

The main objective of the mission has been to acquire launch capability for Geosynchronous satellites. The Indian Space Research Organisation (ISRO) initiated the Geosynchronous Satellite Launch Vehicle (GSLV) project in 1990. The first flight test of GSLV-D1 was intended to validate the various systems of the vehicle in an actual flight although each of the subsystems has been tested on ground. The payload of the first developmental test flight of GSLV was an experimental satellite, GSAT-1, that was to be placed in a Geosynchronous Transfer Orbit (GTO).

The GSLV is a three-stage vehicle that is 49 m tall and weighs about 401 tonne. In designing of GSLV, the scientists and engineers at ISRO made use of several systems that have been tested earlier in the Polar Satellite Launch Vehicle (PSLV) developed by them. The first stage solid propellant motor, the liquid propellant second stage and the first stage liquid strap-on stages for the GSLV were derived from the second stage of PSLV.

The first stage of GSLV which is 20.3 m long and 2.8 m in diameter develops about 4700 kilo newton thrust and burns for 100 seconds. The engines used for the strap-on motors and the second stage are similar and employ a turbo-pump fed engine producing a thrust of about 700 kilo newton in vacuum. Due to the larger propellant loading, the strap-on stages burn for about 160 seconds while the second stage burns for 150 seconds.

The third stage of GSLV uses a Cryogenic Stage (CS) that has been procured from Russia. The stage, that employs liquid hydrogen and liquid oxygen as fuel and oxidizer respectively, is 8.7 m long and 2.9 m in diameter. Liquid hydrogen (LH) and liquid oxygen (LOX) are stored in two separate tanks that are connected by a specially designed inter-stage structure. The stage can burn for a duration of about 750 seconds producing a nominal thrust of 75 kilo newton.

The different stages of GSLV are connected by inter-stage structures, which also house the necessary avionics and control systems for controlling the lower stage till it is separated. Its design enables firing of the second stage even while the first stage has just completed its thrusting action. This design helps to avoid use of additional systems needed to provide sufficient acceleration between the usual time gap before the ignition of second stage takes place and sufficient reduction in velocity of the first stage. The first stage, including the core and four straps on motors after its function, gets separated from the rest of the vehicle.

The vehicle equipment that includes the vehicle electronic systems like processors, navigation system, control system, guidance system, telemetry system, tele-command system, etc, is housed above the cryogenic stage. The spacecraft is mounted above the equipment bay. A heatshield, which is 7.8 m long and 3.4 m in diameter, has been provided to protect the vehicle electronics that is discarded at about 110 km during the second stage. Opening the band-clamp joint and the springs attached within the separation system that provides the required separation velocity to the satellite separates the spacecraft. The system is designed to ensure that no collision occurs between the spent third stage and the spacecraft.

While the first developmental test flight is primarily intended to validate the vehicle design and its performance parameters as well as the associated ground infrastructure, the flight opportunity was also to be made use of to place an experimental satellite GSAT-1 weighing about 1540 kg. GSAT-1 is carrying two C-band transponders and two S-band transponders which will be used for demonstrating digital audio broadcast, internet services, compressed digital TV experiments and developmental communication.

GSLV is the most technologically challenging mission undertaken so far under the Indian space programme. It is the culmination of efforts of a large number of scientists, engineers and technicians, over the last ten years. The mission will herald a significant milestone towards the establishment of indigenous capability for launching communication satellites like INSAT. Having already established indigenous capability for launching IRS class of remote sensing satellites through PSLV, the launch of GSLV will fulfil the vision of Dr Vikram Sarabhai to make the Indian space programme a self-reliant one, while tuning it towards national development.

One-third of Indians and Chinese are Obese

According to the Chairman of the International Obesity Task Force of the World Health Organisation, one-third of all adults in Indian and China are obese. This, however, need not be construed to be a sign of consumption of highly nutritive dietary habits as a result of an improvement in the economic conditions of the people of the region. These conditions can be equally possible due to severe under nutrition as well. It is estimated that there may be as many as 2.2 billion obese people in India and China alone. China has been identified as the country with fastest rate of weight gain in the world. The rate of rise in the number of obese population in other parts of Asia including India is not lagging far behind and the problem is likely to become an epidemic, if corrective measures are not taken immediately. There are many other reasons that are much more compelling to tackle the problem to curb the menace of obesity. It should not be forgotten that obesity is one of the major causes of diabetes, coronary heart disease, hypertension and cancer. The alarming rise in the cases of high blood pressure and diabetes reported from these regions could have a link with the rise in the number of obese people.

A New Hope for Leukaemia Patients

At present the ultimate treatment available to the leukaemia patients, more commonly known as blood cancer, is bone marrow transplant. But this line of treatment too depends on the availability of suitable donors whose bone marrow could be transplanted in them. Many a patients face a certain death if a suitable donor is not available. Researchers propose to develop a method to build new immune system in adult leukaemia patient using the blood from the umbilical cord. Umbilical cord, it may be recalled, provides the vital link between the mother and her child in the womb to facilitate transport of nutrition and blood. Traditionally the umbilical cord is disposed off as a waste after the birth of the child.

However, the scientists have already established the use of the blood from the umbilical cord for the treatment of children suffering from leukaemia. Until now, the stem cells drawn from the umbilical cord blood were being used exclusively for children. This is because an umbilical cord contains only one-tenth as many stem cells as a marrow donation. The experts believed that there are, therefore, too little tissue to reconstitute the immune defence system of an adult.

However, new research shows that because the umbilical cord cells proliferate so rapidly, they can indeed be used to treat adults. In the first study conducted in the USA on cord blood transplant in adults, as many as 68 adults were given cord blood transplant from unrelated donors. The experiment was conducted at the University Hospital of Cleveland, USA. According to the researchers, many of these patients could not survive for more than a month after the transplant mainly due to complications arising from infections, bleeding and similar other reasons. The number of patients that survived for longer terms was found to be nearly the same as in the case of bone marrow transplant. However, the researchers are optimistic that in the near future it may be possible to replace bone marrow and other sources of stem cells with those drawn from the umbilical cord blood. What is especially notable about the new find is that it would not make patients to wait for suitable donors, as is the case with the bone marrow transplant. Cord blood transplantation holds the promise of making it possible that every one will have a donor.

According to Dr Mary J. Laughlin, the Director of the transplant programme at the University Hospital of Cleveland, the stem cells collected from the bone marrow or the blood circulating in adults or from the cord are immature cells. These immature cells can develop into any type of blood cells whether oxygen-carrying red blood cells, clotting platelets or the infection fighting white blood cells. What is most significant with the use of cord blood cells is that a match with them can be located and prepared within a week while with bone marrow it may take months to do so. Further, the cells from umbilical cord of a newborn are unlikely to contain a virus dangerous to transplant patient that is so common amongst adult donors.

The researchers believe that the cord blood will be used to treat a number of other diseases or ailments that affect humans of all ages throughout the world. Some of the potential areas where the stem cells from umbilical cord are likely to find their use are in repairing of damaged blood vessels in heart patients, repairing of brain tissues in the patients suffering from Parkinson's disease. It is expected it will also be possible to use stem cells from cord blood for replacing pancreas cells that may not be producing enough insulin in diabetics.

A Cost Effective Method to Combat Malaria

The traditional method followed in southern Asia including India, to control breeding and spread of mosquitos that hosts the malaria parasite has been to spray insecticides inside homes and other probable breeding grounds. Use of mosquito nets is another practice adopted in this region to control the disease. The approach, however, is becoming too expensive with the rising cost of insecticides and as a result a large areas remain untreated leading to a high rise in the reported cases of malaria in the region. However, now a team of researchers comprising British and French scientists have found a much simpler and cheaper way to combat the mosquito menace. According to them sponging cattle with a common insecticide could be a simple, cheap and astonishingly effective way for combating malaria especially in southern Asia. Their suggestions are based on the findings of a research study conducted by them in Pakistan.

The research study suggests that sponging cattle with deltamethrin, an insecticide widely used on herds of cattle to control ticks and tsetse flies. In the experiment that was carried in six settlements of Afghan refugees in Northwest Frontier Province in Pakistan, cattle were periodically sponged with deltamethrin over three malaria transmission seasons between 1995 and 1997.

It was known that the local strains of mosquito, *Anopheles stephensi* and *Anopheles cullicifacies*, prefer to suck blood of cattle rather than human beings. The researchers, therefore, hoped that it would be more sensible to attack the mosquitos first of all at their favourite feeding ground. Adoption of technique suggested by them brought down the cases of malaria infection from 56% to 31.5% in the population. The density of life expectancy of the two strains of mosquitos was also found to be reduced substantially. This success, according to the researchers, is comparable with that achieved by home spraying but the cost was nearly 80% less. Moreover, the treatment could be done safely and quickly by local people rather than trained personnel usually deployed from outside. The other advantage of new method is that the toxic effects of the insecticide are much less as compared to home spraying because deltamethrin has no toxic effect on cattle. Whatever little amount insecticide penetrates into the skin, which too is eliminated quickly through metabolic processes with no danger to the consumer.

More New Planets Discovered beyond the Solar System

The world's most successful team of planet hunters had announced discovery of 11 more planets beyond the Solar System. The discovery includes a giant planet whose orbit around its star is quite similar to that of the Earth. The finds boost the tally of known "exo-planets to 63, according to the European Southern Observatory (ESO), whose facilities at La Silla, Chile were used in some of these discoveries. The discoveries were made by an international team of astronomers drawn from Geneva Observatory in Switzerland, Haute-Provence and Grenoble observatories in France, the Centre for Astrophysics at Cambridge, Massachusetts and the Tel Aviv University in Israel.

The detections include a giant planet found in a 'habitable' zone near a Sun-like star, designated HD 28185. The planet's orbit is very circular and had a year that lasts for 385 days, just 30 days more than an Earth year. In addition, its distance from the star, which is 150.6 million km, is almost equal to the distance between the Sun and the Earth, i.e. 149.6 million km. However, the planet is gaseous giant, at least three and a half times the size of Jupiter, and is unlikely to be a place where life could develop. Nevertheless, it may have one or more moons on which a more bio-friendly environment has evolved. The presence of natural satellites ('moons') around giant extra-solar planets is not a far-fetched idea— just like in our own Solar System.

In contrast, a planet swinging around the star, HD 80606, has been found to have the most elongated orbit of any exo-planet discovered so far. It moves between five million and 127 million km in its orbit, which implies huge extremes of heat and light. Other finds belong to two stars, designated HD 82943 and HD 74156, each having been found to have two planets. They bring to six the number of known multi-planet systems. Exo-planets have sparked fewer speculation about the prospects for life elsewhere in the Universe, although so far none has been found to be a match for the Earth.

Self-clearing Ability of the Earth on Decline

According to a study published in a research journal the earth's atmosphere is beginning to lose its natural ability to remove air pollutants, a condition that could spread smog and accelerate the accumulation of greenhouse gases.

The study documents for the first time a modest, two-decade-long worldwide decline of a key molecule that cleanses the air. Without enough of these molecules, emissions that contribute to the greenhouse effect, smog and the hole in the ozone layer do not get destroyed as fast as humans release them. According to Ronald G. Prinn leader of the 13-member research team from the Massachusetts Institute of Technology, USA, this one molecule is very very important. It is the critical cleaning chemical for the atmosphere. If this free-radical (molecule) is decreasing, it could add to global warming. But the experts estimate that the losses of the chemical, called a bydroxyl radical, are slight so far and are not current cause for alarm.

Terry Keating, environmental scientist for the US Environmental Protection Agency, however, acknowledges that though there are a number of research findings that demonstrate the global atmosphere is changing, but we really do not know the exact causes. Indeed, some scientists say more research is necessary to understand the complex chemical reactions that occur in the atmosphere. Also, they say it is not clear whether the molecule's decline is a temporary or cyclical event or one that protends a long-term shift.

Nutrino Mystery Solved

Physicists have found the most convincing evidence yet that neutrinos — subatomic particles that were thought to have no mass whatsoever — have after all has some mass. The discovery is likely to pave the way to solve a 30-year-old scientific mystery. It may be recalled that ever since their existence was first hypothesized by Wolfgang Pauli, neutrinos have been thought of as massless.

The finding means scientists will have to revise their theories of the universe to adjust for the new findings. Kevin Lesko, a physicist at Lawrence Berkeley National Laboratory, USA who has helped design and in conducting the experiment observes that he is quite pleased with this result.

But the representatives of the Sudbury Neutrino Observatory in Canada announced in the third week of June 2001 that neutrinos made by nuclear reactions in the Sun's core change from one type to another during their journey to Earth. And only particles with mass can change form. The neutrino's mass cannot be much, around a mere billionth of that of a proton. But its mere existence has profound implications.

The standard model, the reigning theory in particle physics, does not allow particles that change their flavour to have mass. So that theory will have to be patched up, though not discarded, to accommodate the new observations.

Two New Dinosaurs Found

Scientists have unearthed two new species of dinosaurs in New Mexico, including a bizzare one that sprang from the same lineage as super carnivore Tyrannosaurus rex but was content to eat plants. The two dinosaurs — the weird, sloth-like Nothronychus and a small carnivore from the coelurosaur family that has not yet been named — lived 90 million years ago in a swampy forest similar to the bayous to Louisiana, according to paleontologists Jim Kirkland and Doug Wolfe, who announced the discovery.

'Scientists believe that both the dinosaurs had bird-like characteristics and were probably covered with feathers. They were found about a 800 metre apart near New Mexico's border with Arizona in a area dubbed the Zuni Basin, which had been just a few kilometre from the shores of a sea 1600 km wide that of split North America. At that time — the middle of the Cretaceous period of the Mesozoic era – Earth was in the throes of extreme global warming that melted the polar ice caps, raised ocean levels 300 metres higher than they are at present and reduced the amount of dry land on the planet. The discovery is a special because almost no dinosaur fossils have been found from that time, particularly in North America. According to Tom Holtz, a palaeontologist from the University of Maryland, USA who contributed to the research the discovery opens a window on a time period that otherwise we wouldn't know about.

The Nothronychus (pronounced "no-thron-EYE-kus") is a member of the theropod class of meat-eating dinosaurs that includes Tyrannosaurus and Allosaurus, but it apparently evolved into a plant-eater, said Kirkland, the state paleontologist for Utah. It weighed about a ton, was 4.5 to 6 metre long and stood 3 to 4 metre tall. The creature was bipedal and walked more upright than its carnivore cousins, had a long, thin neck, long arms, dexterous hands, 10 cm curved claws on its fingers, a large abdomen, a small head with a mouth full of leaf-shaped teeth designed for shredding vegetation, a relatively short tail and stout back legs, claimed the scientists. They described them truly, truly bizarre.

Spacecraft Galileo Swings close to Jupiter Moon

The U.S. spacecraft Galileo made its closest pass yet to Jupiter's outermost moon Callisto early on 25 May 2001. The spacecraft passed Callisto at a distance of 100 km from its surface — a closer range than any of Galileo's 30 previous Jovian moon flybys, said Eilene Theilig, Galileo project manager at NASA's Jet Propulsion Laboratory in Pasaden.

According to NASA the Galileo's camera worked well throughout the pass-by Callisto, and data on that moon will be sent back to Earth over the next few months. The craft is on track to pass near another moon, Io, in August this year.

The spacecraft has been orbiting Jupiter since 1995 and was supposed to have ended its mission in 1997. But the mission was extended as Galileo continued to produce scientific discoveries. Its closest previous encounter with a moon was at 200 km distance of Io in February 2000. Its closest encounter to Jupiter itself was at 458,650 km from the planet's cloud tops on May 23. It will pass some 20 per cent closer to the planet on a new orbit when it flies by the volcanic moon, Io, in August this year.

Artificial Heart to be Implanted

Sometimes in the last week of June 2001, a heart patient on the brink of death from cardiac failure is likely to receive a self-contained, battery-powered mechanical heart that the researches hope will enable him to sustain life for at least another 60 days. Heart surgery teams at five hospitals in the USA are trained and poised to remove a failing natural heart and install in its place the first total replacement artificial heart designed to fit inside the chest without connections through wires and conductors but the skin.

The developers of the mechanical heart have planned that the transplant of the artificial mechanical heart would proceed without prior announcement with patient's identity closely guarded. Results of the procedure would not be made known to the public for at least 30 days. The company that have developed the mechanical heart has received necessary approval to perform at least five human trials with the artificial heart. If the experiments are successful, more patients could be added to the trial later.

Poor in Mathematics, Blame it on Iron Deficiency

A study conducted by the US researchers may help to explain why boys tend to do better than their female counterparts in maths class by the time they reach high school. The researchers have found that iron deficiency may affect children's ability to understand maths problems.

The study of nearly 5,400 children aged 6 to 16 years found that those who were deficient in iron were more than twice as likely to score below average on standardized maths tests than their more well-nourished peers. The findings suggest that girls, who are at greatest risk for iron deficiency, were particularly vulnerable to the mineral's effect on learning, particularly mathematics.

Iron is essential for the production of red blood cells, and deficiency in the mineral can lead to anaemia, or having too few red blood cells. Most studies on learning and iron deficiency have focused on people with iron-deficiency anaemia, and not the larger group of individuals who are iron-deficient but do not have anaemia.

The findings suggest that doctors should screen certain patients for iron deficiency. If these findings are confirmed, then screening for iron deficiency, particularly for those children without anaemia, might be warranted for high-risk children according to Dr Jill S. Halterman, a member of the research group. She asserted that it is possible that preventive iron supplementation, or treatment for those children who are affected, would prevent the potentially negative cognitive effects of iron deficiency.

However, Halterman cautioned that it is not yet clear whether learning problems can be corrected through iron supplementation. Halterman and colleagues explain that nutrition needs during a period of rapid growth, loss of blood due to menstrual periods and poor diets make adolescent girls susceptible to iron deficiency. Iron deficiency results in decrease in iron stores in the brain, where it may affect enzymes and neurotransmitters that impact learning.

Compiled and edited by
R. Joshi

Book Review

Artificial Intelligence

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GREAT ADVANCES have taken place in computer technology. Today, computers are being used not only in solving complex mathematical problems but in a host of diverse fields too. Despite great capabilities of computers they are still far from being at par with the ingenuity of the human brain. Computer scientists are, therefore, busy evolving computers that could simulate or mimic the human brain. Called the 'fifth' generation computers, they exhibit semblance to human intelligence. The instilling of 'artificial' intelligence in computers holds a vast potential as it has applications in a plethora of fields. A whole new branch of artificial intelligency (AI) has been evolved in which a lot of research is being carried out. Expert systems have been evolved, thanks to the AI research. These systems have proved extremely useful in such diverse fields as medical diagnosis, geophysical resource exploration and industry.

Systems have also been evolved where computers are used for natural language processing. Today; some machines are available which can recognise spoken words and simple sentences. Robotics is another major area of AI research. Autonomous or intelligent robots not only can assist in the efficient running of huge factories but can also save precious manpower in various other walks of life, too. Artificial intelligence is, therefore, quite a promising field. The book under review aims at unravelling the scope and many facets of the AI research.

An analogy between computer and human brain is often made. Although the working mechanism of a computer seems to be akin to that of the brain, however computers do lack the intelligence or intellectual abilities of human beings. Instilling artificial intelligence in the machines is, therefore, the aim of the AI research. However, an insight into the functioning of the human brain is essential before one can pose the question whether its electronic equivalent can be constructed.

The human brain is endowed with such attributes as 'learning', 'memory', 'thinking' and 'pattern recognition'. All these processes including language interpretation and speech generation actually take place in a thin layer on the brain surface called cortex. The process of learning, according to Hebb's theory, involves strengthening of linkages between many thousands of neurons in the brain. An actual learning process, therefore, involves forming new links between individual cells or between associations of cells that already exist.

Memory is a very essential attribute of human brain. Three basic forms of memory possessed by humans are intermediate, short-term and long-term memories. The information in the intermediate memory is retained for merely 1/10th of a second like a badminton player returning a shuttlecock while the short-term memory (also known as working memory) retains the information for about a few minutes. However, by repeating the information over and over again short-term memory can be transformed to the long-term memory e.g. learning a poetry by heart.

Thought process and decision-making are other important characteristics of human beings. Through learning one acquires new knowledge. Knowledge has also been categorised into various groups e.g. casual, procedural, declarative, tacit, deep, shallow and heuristic knowledge. Language acts as a very powerful vehicle in widening the scope of human knowledge. All these details about learning, thinking, memory, knowledge etc. appear in the chapter 'Learning and Memory'.

The idea of constructing machines that could think came in the late 1940s with the development of a machine called *Enigma* by Alan Turing. In fact, this machine came into existence for dechiphering the coded German messages during the World War II. However, Turing's ultimate aim was to design machines which understood the general logical operations like AND, NOT and OR and could process non-numerical symbols. Turing's ultimate dream, however, remained unfulfilled due to his premature death in 1954.

A group of eminent computer scientists gathered at the American Dartmouth College in the summer of 1956 to discuss about the possibilities of developing 'thinking' machines. Many promising and bizarre new ideas were exchanged in the meeting. It is only after this meeting that the term 'AI' came into common usage. Strictly speaking, AI refers to an academic discipline where one studies how human beings behave intelligently and how machines could emulate this intelligent human behaviour.

For development of 'intelligent' machines, programming of the proper (AI) language is an essential prerequisite. The basis of such programming is logic which is the science of reasoning. Syllogism evolved by Aristotle is a simple example of formal logic. However, logic in symbolic form (where symbols and notations are used instead of words as in formal logic) was first introduced by Leibnitz about 300 years ago. However, somehow it did not catch on. It was George Boole who about hundred and fifty years ago rediscovered symbolic logic. The Boole's logic dealt with abstraction of concepts into symbols and connecting them (through connectives such as 'or', 'and', 'not' etc.) to form logical statements. The connectives enable the determination of the truth or falsity of the logical statements.

The symbolic logic is categorised into two distinct but interrelated branches, namely, 'propositional' logic and 'predicate' logic. While propositional logic deals with the truth or falsehood of statements, the predicate logic goes one step further by introducing the relationships between individual objects or classes of objects. A symbolic statement like 'The boy plays football' can be written in predicate format as *play (boy, football)*. In the above statement the two items *boy* and *football* are related through the verb *play*. The items are known as 'arguments' and the relationship is known as 'predicate'. Predicate logic is the basis of programming the AI language PROLOG. Another programming language that has been widely used for developing expert (AI) systems, particularly in the US, is LIPS or List Processing. Created by John McCarthy, LIPS is a functional language capable of manipulating symbols as well as structures rather than just numerical calculations. It has, therefore, vast potential in the field of AI.

By far the best manifestations of AI are the expert systems. An expert system, also known as knowledge based system, differs from a conventional database programme. In medicine, for instance, a database may be useful for enumerating the symptoms of different illnesses. However, the diagnosis of an illness along with the attendant causes and a possible remedial treatment can be furnished only by an expert system. The first successful expert system was developed in the mid 1970s by Edward Feigenbaum and Edward Shortliffe at the Standford University. Dubbed *Mycin* it was a expert system meant for medical diagnosis of infectious diseases of the blood. Another expert system evolved for the diagnosis of lung diseases was *Puff*. In the field of geology and mineral prospecting too an expert system, known as the *Prospector*, was developed. Research for developing more expert systems is underway. Probably one day it would be possible to develop expert systems that would provide advice on legal matters as also matters related to tax and insurance.

With the popularisation of expert systems, the computer designers were prompted to think in terms of introducing new interfaces between the machines and their users. The systems emerging as a result of this interfacing were termed as 'user friendly'. The genesis of user friendly systems is that the computer can interact with the human user in a language that the user is already familiar with unlike in conventional computers where the user has to learn the specific computer language to programme instructions into the computer. Natural language systems have been developed which comprehend the instructions given in ordinary English. Going one step further, it has even been possible to design machines called sonographs. However, more research in speech science is needed before such artificial speech recognition systems can approach anywhere near human performance.

Although AI has yet to cover a long terrain it has already made its niche. There is no gainsaying that AI would certainly bring a sea change in the information and knowledge processing the world over in the coming decades. The scope of AI and the concepts related to it have been brought home in the book under review in a systematic and interest arousing manner. Although targeted for the non-specialist the book is expected to benefit a wide cross-section of readers.

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Learn More About Diamonds
Structure, Properties, Applications and Future Prospects

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Diamond has been prized for centuries with a special place in the hearts and minds both of scientists and the common man. Diamond is very precious to mankind. For some, the word diamond conjures up images of brilliant gem stones of exceptional brilliance and lustre, wealth and special occasions. To the scientists, diamond is impressive because of its wide range of exceptional and extreme properties. Diamonds are very hard. They resist blows to such an extent that the hammer rebounds and the very anvil splits asunder.

Structure and Stability

Diamond is composed of the single element carbon, and it is the arrangement of the C atoms in the lattice (Fig. 1) that give diamond its amazing properties. Compare the structure of diamond and graphite, both composed of carbon only. In diamond we have the hardest known material, in graphite we have one of the softest, simply by rearranging the way atoms are bonded together. The relationship between diamond and graphite is a thermodynamic and kinetic one, as can be seen in the phase diagram for carbon (Fig. 2). At normal temperatures and pressures, graphite is only a few eV more stable than diamond, and the fact that

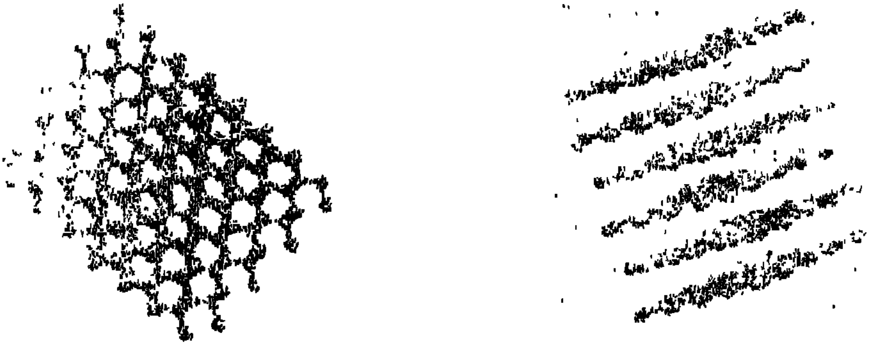
(A) (B)

Fig. 1(A) Diamond lattice and (B) Graphite lattice

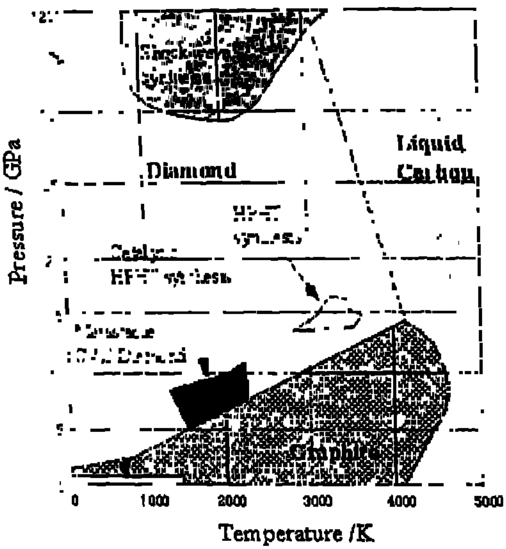

Fig. 2 Phase diagram for Carbon

diamond exists at all is due to the very large activation barrier for conversion between the two. There is no easy mechanism to convert graphite into diamond and vice-versa. So interconversion requires almost as much energy as for destroying the entire lattice and rebuilding it. Once diamond is formed, it cannot be recovered back to graphite because the barrier is too high. So diamond is said to be metastable, since it is kinetically stable, not thermodynamically stable. Thermodynamically graphite not diamond, is the stable form of solid carbon at ambient pressures and temperatures. Diamond is created deep underground under conditions of extreme pressure and temperature. Under these conditions diamond is actually the more stable of the two forms of carbon, and so over a period of millions of years carbonaceous deposits slowly crystallise into single crystal diamond gemstones.

Properties

When compared to almost any other material, diamond almost always comes out on top. Choose virtually any characteristic of a material—electronic, structural, or optical — and the value associated with diamond will almost always be the most extreme. As Table 1 shows, by most measures diamond is the 'the biggest and best'; it is the hardest known material, has the lowest coefficient of thermal expansion, is chemically inert and wear resistant, offers low friction, has high thermal conductivity, is electrically insulating and optically transparent from the ultra-violet (UV) to the far infrared (IR). It is the least compressible, and the stiffest material.

Uses

Given these many notable properties, it should come as no surprise to learn that diamond already finds use in many diverse applications including, of course, its use as a precious gem, but also as a heat sink, as an abrasive, and as inserts and/or wear resistant coatings for cutting tools. Obviously, given its many unique properties it is possible to envisage many other potential applications for diamond as an engineering material, but progress in implementing many such ideas has been hampered by the comparative scarcity of natural diamond. Hence the long running quest for

Table 1
Some of the outstanding* properties of diamond

Property	*Value and Units*
Hardness	10,000 kg/mm^2
Density	3.52 g/cm^3
Thermal expansion coefficient	0.0000011/K
Thermal conductivity	20.0W/cm-K
Strength, tensile	1.2 Gpa
Strength, compressive	110 Gpa
Sound velocity	18,000 m/s
Young's modulus	1.22 Gpa
Poisson's ratio	0.2
Thermal shock parameter	30,000,000 W/m
Debye temperature	2,200 K
Optical index of refraction (at 591 nm)	2.41
Optical transmissivity (from nm to far IR	225
Loss tangent at 40 Hz	0.0006
Dielectric constant	5.7
Dielectric strength	10,000,000 V/cm
Electron mobility	2,200 cm^2/V-s
Hole mobility	1,600 cm^2/V-s
Electron saturated velocity	27,000,000 cm/s
Hole saturated velocity	10,000,000 cm/s
Work function/Electron affinity	small and negative on [111] surface
Resistivity	10^{13} - 10^{16} Ohm-cm

* Good electric insulator (room temperature resistivity is ~10^{16} Ω cm)
Diamond can be doped to change its resistivity over the range 10-10^{16} Ω cm, so becoming a semiconductor with a wide bad gap of 5.4 eV.
Very resistant to chemical corrosion.
Biologically compatible.
Exhibits low or 'negative' electron affinity.

routes to synthesise diamond in the laboratory.

Classification

Diamonds are classified by the type and level of impurities found within them.

(A) Natural Diamonds

- Type Ia diamond — Most natural diamonds are of this type, which contain up to 0.3% nitrogen.
- Type Ib diamond — Very rare (~0.1%) in nature, but almost all synthetic (industrial) diamonds are of this type. They contain nitrogen at concentrations of up to 500 ppm.
- Type IIa diamond — Very rare in nature, these diamonds contain so little nitrogen that it can't be easily detected by the usual IR or UV absorption measurements.
- Type IIb diamond — Extremely rare

in nature. These have such a low concentration of nitrogen (even lower than type IIa) that the crystal is a p-type semiconductor.

(B) Synthetic Industrial Diamond

These have been made since the early 1950's, by a process called High Pressure High Temperature synthesis (HPHT). This is an attempt to mimic the conditions under which natural diamond forms deep in the earth. Graphite is put into a huge hydraulic press at high temperatures and pressures, and with the addition of a metallic catalyst, converts to diamond over a period of a few hours. The diamond crystals that are produced by this method are typically a few mm in size, which are too flawed for use as gemstones, but are extremely useful as hard-wearing edges on cutting tools and drill-bits.

(C) Thin Film Diamond

World interest in diamond has been further increased by the much more recent discovery that it is possible to produce polycrystalline diamond films, or coatings, by a wide variety of chemical vapour deposition (CVD) techniques using methane in an excess of hydrogen. This is creating a great deal of excitement in the academic community, since for the first time we have access to all the superlative properties of diamond in a form that is useful for engineering applications. This CVD diamond can show mechanical, tribological, and even electronic properties comparable to those of natural diamond. We can imagine hard-wearing diamond coatings on machine parts, diamond windows, diamond electronics, diamond displays, diamond fibre reinforcements, and a whole host of other applications. There is currently much optimism that it will prove possible to scale CVD methods to the extent that they will provide an economically viable alternative to the traditional HPHT methods for producing diamond abrasives and heat sinks, whilst the possibility of coating large surface areas with a continuous film of diamond will open up whole new ranges of potential application for the CVD methods.

Present Applications and Future Prospects of the Use of Diamonds

A number of areas of application of diamonds are gradually beginning to appear some of them are presented below.

Thermal Management — Natural diamond has a thermal conductivity roughly four times superior to that of copper, and it is an electrical insulator. It should therefore come as little surprise to learn that CVD diamond is now being marketed as a heat sink for laser diodes and for small microwave integrated circuits. Reliability can be expected to improve also since, for a given device, junction temperatures will be lower when mounted on diamond.

Cutting Tools — CVD diamond is also finding applications as an abrasive and as a coating on cutting tool inserts. CVD diamond-coated drill bits, reamers, countersinks etc. are now commercially available for machining non-ferrous metals, plastics, and composite materials. Initial tests indicate that such CVD diamond-coated tools have a longer life, cut faster and provide a better finish than conventional tungsten carbide tool bits.

Wear Resistant Coatings — In both the previous applications, CVD diamond is performing a task that could have been fulfiled equally well by natural diamond if economics were not a consideration. However, there are many other applications at, or very close to, the market place where CVD diamond offers wholly new opportunities. Wear resistant coatings are one such use. The ability to protect mechanical parts with an ultra-hard coatings, in gearboxes, engines, and transmissions, may allow greatly increased lifetime of components with reduced lubrication. The phrase non-ferrous is worth emphasising here since it reminds us of one of the biggest outstanding challenges in the application of diamond film technology — whether as a wear-resistant coating or as fine abrasive. In any application where friction is important the diamond-coated tool bit will heat up and, in the case of ferrous materials (be it the tool substrate or the workpiece) the diamond coating will ultimately react with the iron and dissolve. Intense research efforts into suitable barrier layer materials to allow diamond coating of iron and steel machine parts are currently underway.

Optics — Because of its optical properties, diamond is beginning to find uses in optical components, particularly as protective coatings for infrared (IR) optics in harsh environment. Most IR windows currently in use are made from materials such as ZnS, ZnSe, and Ge, which whilst having excellent IR transmission characteristics, suffer the disadvantages of being brittle and easily damaged. A thin protective barrier of CVD diamond may provide the answer, although it is more likely that future IR windows will be made from free-standing diamond films grown to a thickness of a few mm using improved high growthrate techniques.

Electronic devices —The possibility of doping diamond and so changing it from being an insulator into a semiconductor opens up a whole range of potential electronic applications. However, the fact that CVD diamond films are polycrystalline and hence contain grain boundaries, twins, stacking faults, and other defects, which all reduce the lifetime and mobilities of carriers. This remains a major limiting factor in the development of diamond devices.

One potential application which is causing a great deal of interest at the moment is the idea of using diamond as an electron emitter in flat panel displays. The diamond tracks would be negatively biased, causing them to emit electrons which are then accelerated by the gate electrode to strike the phosphor screen, thereby creating light.

The electronic properties of diamond are such that when it is biased negatively in vacuum, electrons are ejected from its surface. This process is also common to most metals, except that in metals the electron has to overcome an energy barrier, or work function, to escape from the surface. In diamond this barrier has been measured and found to be very small, maybe even negative, and this has given rise to the term negative electron affinity. In practice, this means that devices based upon diamond's electron emission properties could consume very low power levels and hence be extremely efficient. The electrons emitted from the surface are accelerated using a positively biased grid, and then strike a target. The target material determines what type of device is made. If the target is a phosphor screen, light will be emitted where the electrons strike it, and we have tube basis for a flat panel display. Each emitting diamond crystal, or group of crystals would form a 'pixel' on the screen. Unlike their major competitors (liquid crystal displays), diamond cold cathode emission displays would have high brightness, have a large viewing angle, and most importantly, have the ability to be, scaled up to large sizes (maybe even metres square!). Alternatively, if the target material is a conductor capable of collecting current, the emission device could form the basis of an ultra-fast switch, so suggesting the possibility of faster computers.

Composite Materials —Another interesting development in diamond technology is the ability to deposit CVD diamond onto the outer surfaces of metal wires or non-metallic fibres. Such diamond-coated fibres make them extremely stiff for their weight. If growth rates can be increased to economically viable levels, such diamond fibres may find uses as reinforcing agents in metal matrix composites, allowing stronger, stiffer and lighter load-bearing structures to be manufactured for use in, say, aerospace applications. Furthermore, etching out the metal core of the diamond-coated wire using a suitable chemical reagent yields free-standing diamond tubes, or hollow diamond fibres. These too have potential applications for reinforcing smart composites, since the hollow cores may provide conduits for sealant, coolant, or sensors to be placed into the reinforced structure. Two-dimensional mattings or weaves of diamond-coated fibres have also been suggested as reinforcing agents.

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Looking Into Leukaemia

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CANCER evokes dehumanised feelings. The person with cancer generally fears that his disease and the burden of its treatment will force his near and dear ones to flee from him. This makes cancer the most feared illness in the world. For most of the people, irrespective of their education and knowledge, the word *cancer* is synonymous with death. One of the most dangerous types of cancer is the cancer of blood, i.e. Leukaemia. This disease eludes early detection and manifest itself in humans of all ages, caste and creed. According to experts, Leukaemia cases are expected to increase rapidly in coming years. But the recent development, i.e. mapping of human genome has given new targets and tools to experts for early detection and treatment of this disease. Knowledge of human genome guides scientists to locate defects in genes and enzymes. Improvement in imaging techniques, radiotherapy, immunotherapy, molecular target therapy and the availability of biomarkers will speed up diagnosis and treatment of Leukaemia. Surgery will disappear as a major treatment. New pills tailored for tumours will provide maximum impact and minimum discomfort. New treatments will be simpler to administer. A pill called Gleevec which thwarts the malfunctioning of enzyme responsible for Leukaemia has been recently cleared by the US Food and Drug Administration for the treatment of Leukaemia. Many of further advances will be resulting from this decoding of human genome, the so-called human book of life. In coming times, gene chips will be implanted under the skin to send radio-signals to home computer when an abnormal piece of DNA is detected, promoting quick diagnosis and treatment.

Leukaemia is a group of diseases which describes a variety of cancers of white blood cells, i.e. leukocytes. It was first recognised by Virshow in 1849. His statement, "During normal blood cell production the precursor cells differentiate into specific types and in pathological situation, i.e. Leukaemia, this process of differentiation is blocked", remains essentially correct even today. Leukaemia is marked by an abnormal and widespread proliferation of leukocytes and their precursors in the tissues, which pass on later into living fluid circulating into every nook and corer of the human body, i.e. the blood. This disease originates in three well defined areas of the body—bone marrow, lymph nodes and spleen. Two main types of Leukaemia are lymphatic and myeloid. Lymphatic Leukaemia arises due to malignancy of the lymphatic system and as a result circulating blood contains large number of lymphocytes. Myeloid Leukaemia arises from leukocytes forming myeloid cells of the bone marrow and is characterised by an enormous ponderance of granulocytes in circulation together with blast cells. Blast cells are primitive cells which escape into circulation from bone marrow before maturation. Both of these Leukaemias can be either acute or chronic.

White cells act as a protective army of the body. How they acquire neoplastic propensities and become leukemic, is one facet of the larger mystery of the cause of blood cancer. Scientists have discovered that blood cells become leukemic when their normal genetic machinery goes out of order. DNA is the master molecule that encodes the genetic script of life. The triggering factors which disturb the normal genetic machinery include — radiation, virus, environmental poisons, toxic chemicals, defective genes or a combination of all these. These causative factors bring about mutation or deletion of an enzyme system which exert control on cell division. Unfortunately, it is very difficult to locate the erratic gene within the vast ocean of genes and further manipulation of that gene is really a herculean task. But human endurance is limitless. Mapping of human genome has solved the problem of locating the defective gene to great extent.

Leukaemia causes the white blood cells to increase in number to the point that the other blood cells, e.g. red blood cells and platelets are crowded out and anaemia develops. With a decrease in blood platelets, the blood ability to clot is reduced and bleeding disorders develop. Common symptoms which help in diagnosis of this disease include — pallor, malaise, night sweats, heat intolerance, fever, pruritus, easy fatigue, pneumonia, thrombocytopenia resulting in small purplish spots on the skin, infections of skin, bleeding specially from nose and gums, enlargement of lymph nodes, hepatomegaly, spenomegaly leading to feeling of early satiety, therefore reduced food intake and weight loss.

Modern analytic techniques such as nuclear magnetic resonance, electron spin resonance, photon induced x-ray emission and Mossbauer spectroscopy have helped scientists in understanding the molecular basis of this disease. The therapeutic agents for Leukaemia should be able to destroy malignant cells without harming the normal cells. Traditionally Leukaemia has been treated by radiotherapy, chemotherapy, immunotherapy, bone-marrow transplantation or combination of these. Discoveries in radiotherapy have led to more effective schedules of dose fractionation and timing. Newer rotational techniques and better shielding devices have helped to spare normal tissues while ensuring a more uniform dose of radiation within a specified volume of malignant tissue.

Radiosensitivity of malignant cells can be increased by radiosensitizers, e.g. halogenated pyrimidine analogs. Physical absorption of heavy particles (neutrons) and charged particles such as protons and helium ions creates unit path in tissue. Most of the chemotherapeutic agents interfere with the synthesis of DNA, RNA or protein by some mechanism. When coupled with surgery and radiotherapy, chemotherapy increases the cure rate. However, with chemotherapeutic drugs nausea, vomiting, diarrhoea, gastrointestinal ulcers, side effects are anticipated. Seventy-five per cent of patients with leukemia die of infections. Immunotherapy is aimed at stimulating and strengthening the body's defence mechanisms against leukemic cells. By bone-marrow transplantation, leukemic marrow is replaced by healthy cells. Marrow transplants may be taken from the patient himself or from his relative or sibling. Marrow transplantation, once considered a desperate form of therapy in end-stage of patient has now become increasingly successful when used early in the course of leukemia.

The leukemia patient's nutritional status is constantly being challenged by disease itself, as well as by treatment with high-dose chemotherapy, immunotherapy and/or total body irradiation and bone marrow transplantation. The most important responsibility of the dietician is to follow the therapy of each patient closely, since his condition may change rapidly, and to adjust his diet accordingly in an effort to maintain his optimal nutritional status.

Modified Procedure of Volumetric Experiments
Use of Microscale Technique

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The scaling down of quantities* can also be extended to other experiments like volumetric analysis. For example, the volumetric experiments can be performed with quantities 10 ml or less and using concentrations 0.05 N or less.

At present, a titration is done by using a pipette, a burette and a conical flask. It has been realised now that taking any solution by a pipette may prove to be dangerous. Sometimes, the solution sucked by a pipette may be corrosive or toxic or may be strong enough to damage the mouth. Hence it is recommended that use of a pipette for titration should be abandoned wherever possible. Instead, a burette may be used to take a fixed volume of the solution. Where high accuracy of titration reading is expected, this method can be used by using a microburette. This method is called a two burette method.

Two Burette Method

Let us consider a simple titration between HCl solution (approx. 0.05 N) and NaOH solution (0.05 N) using phenolphthalein indicator. Let us say that we take HCl solution as a titre (a solution with unknown concentration) by burette 1 and NaOH solution as a titrant (a solution with known concentration) by burette 2. Let us say that we take 10 ml of 0.05 N HCl by burette 1 in a conical flask. We add to it 3 to 4 drops phenolphthalein indicator. Since the medium is acidic, the solution remains colourless. Now we add NaOH solution drop by drop from burette 2. At some stage the indicator changes its colour i.e. the solution becomes pink. We note this burette reading B_1. To the pink solution in the conical flask, now we add one ml HCl solution from burette 1. Since the solution in the conical flask becomes acidic, the indicator changes its colour and the solution becomes colourless. To the same solution, without adding any indicator, we again add drop by drop NaOH solution from burette 2. At some stage, the indicator again changes its colour i.e. the solution becomes pink. We note this burette reading B_2. To the pink solution in the conical flask, we add one ml HCl solution from burette 1. Since the solution in the conical flask is acidic, the indicator changes its colour and the solution becomes colourless. To this solution, without adding any indicator, we add NaOH solution from burette in the same manner as before. At some stage, the indicator changes its colour , i.e. the solution becomes pink. We note this burette reading B_3. In this manner, everytime we add one ml HCl so that the solution becomes colourless and then add NaOH solution in a dropwise manner till the solution becomes pink. We take at least five burette reading B_1 to B_5. Thus the titration can get over by using 14 ml HCl and about 15 ml NaOH as against the volume of 30 to 40 ml HCl and NaOH usually required by the conventional method.

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* Refer to the article titled 'Microscale Experiments in Inorganic Chemistry' *School Science*, June, 2001.

Observation Table

Titration between 10 ml HCl (approx. 0.05N) and NaOH (exact 0.05 N)

Titre — HCl (Approx. 0.05 N)

Indicator — Phenolphthalein

Equation — $NaOH + HCl = NaCl + H_2O$

Titrant — NaOH (Exact 0.05 N)

End Point — Colourless to pink

Titre	*Titrant*
10 ml	B_1 ml
11 ml	B_2 ml
12 ml	B_3 ml
13 ml	B_4 ml
14 ml	B_5 ml

Calculations

$$\underset{HCL}{N_1V_1} = \underset{NaOH}{N_2V_2}$$

1. $N_1 \times 10 = 0.05 \times B_1$
2. $N_2 \times 11 = 0.05 \times B_2$
3. $N_3 \times 12 = 0.05 \times B_3$
4. $N_4 \times 13 = 0.05 \times B_4$
5. $N_5 \times 14 = 0.05 \times B_5$

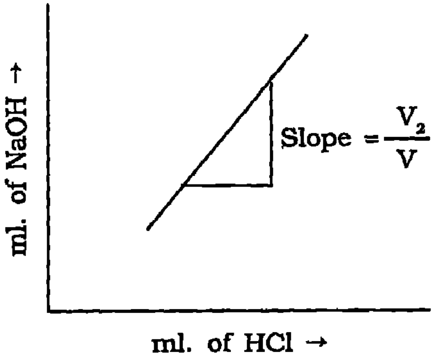
Normality of HCl, N =

$$\frac{N_1 + N_2 + N_3 + N_4 + N_5}{5}$$

Thus the exact normality of HCl can be found out. If we continue the titration to take 16 readings i.e. till 25 ml HCl is titrated, we can plot a graph of volume of NaOH added against the volume of HCl taken. It will be a straight line.

$$\underset{HCl}{NV} = \underset{NaOH}{N_2V_2} \quad \text{Or} \quad V_2/V = N/N_2$$

Since V_2/V is known by graph, N can be found out. The result obtained by graphical method is much more accurate than the result obtained by calculation.



Further, if we want to reduce the volume of solution used for the titration, we can use a microburette and take an interval of 0.5 ml or less instead of 1.0 ml for pilot reading. For the exact reading, we add the titrant solution drop by drop will we get the end point.

This method can be applied to all acid-base titrations with conventional indicators like phenolphthalein, methyl orange and bromothymol blue. The method can also be applied for redox titrations, iodometric titrations and other titrations where regeneration of indicator is possible.

It is known that when we reduce the normality of the solution the pH range in which the indicator shows the colour change is reduced, thereby creating a cause of error. However, when we reduce the normality from 1 N to 0.1 N, the titration error is only 0.2 per cent and when we reduce the normality from 0.1 to 0.01 N, the titration error is only about 1 to 2 per cent. Similarly, when we reduce the volume of solution taken for titration to less than 10 ml, we create a cause of error in the result. However, the percentage error is much less. These errors are within the practical limits at student level. So, looking at the advantages, the method can be recommended at school and college level.

This method has the following advantages :

1. No solution is sucked by mouth so the method is safe.
2. Volume of solution required for the total titration is less.
3. Indicator is added only once.
4. Time required for the titration is less.
5. The results obtained by this method are more accurate than those obtained by the conventional method.

Trisecting an Arbitrary Angle

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THE THREE questions we intend to discuss are the following :

- ☐ Can you trisect an arbitrary angle ?
- ☐ Can you construct an angle of 1^0 ?
- ☐ Can you construct a regular polygon 9 of sides ?

In each case the anser is 'No', if you confine yourself to the use of Euclidean instruments viz straight edge and compasses only.

In each case the answer is 'Yes', if you agree to use an additional instrument called the Tomahawk trisector.

What is Tomahawk Trisector ?

The shape of the tomahawk trisector is shown in Fig. 1. Nobody knows who invented the tomahawk trisector, but it was used in 1835 in France and it can trisect any arbitrary angle.

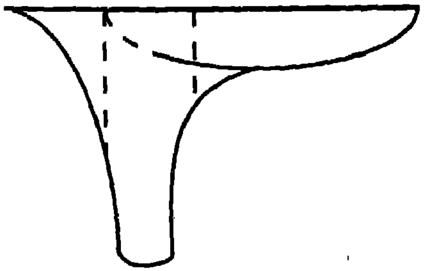

Fig. 1

Its essential features are shown in Fig. 2.

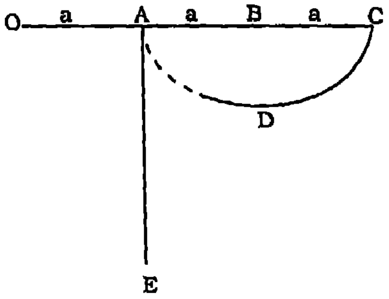

Fig. 2

OABC is a straight line in which OA=AB=BC=a(say).

ADC is a semi-circle of radius a with AC as diameter and B as centre.

AE is a straight line perpendicular to AC and tangent to the semi-circle at A.

How does a Tomahawk Trisector trisect an Angle ?

To trisect an angle MNP we insert the tomahawk trisector in the angle in such a way that its straight line AE passes through the vertex of the angle and the semi-circle touches one of the sides of the angle as shown in Fig. 3. Now

Angle ANB = Angle BNQ

Since AN and NQ are tangents to the circle at A and Q. Also in triangle ONA

$\tan\theta = a/x = \tan\phi$,

so that $\theta = \phi$

Now all the three angles at the vertex N are equal and angle MNP has been trisected by the lines NA and NB.

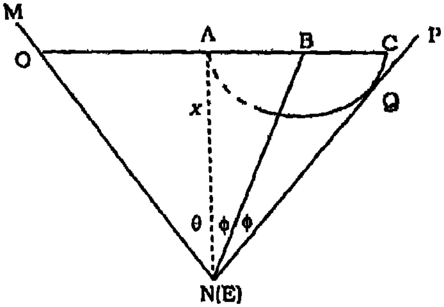

Fig. 3

Constructing an Angle of 1°.

By using straight edge and compasses, we can construct angle of 36° and 30°'s ($\cos 36° = (\sqrt{5} + 1)/4$ and $\sqrt{5}$ can be constructed by straight edge and compasses only), so that we can also construct an angle of 6° and therefore an angle of 3°, but it has already been proved that by using the instrument tomahawk trisector, we can trisect any angle and therefore, we can trisect an angle of 3° to get an angle of 1°. Thus we can also construct any angle of n° where n is a positive integer and we can also construct angle of 1/2°, 1/3°, 1/4°, 1/6°, 1/8° and in general of $1/2^m 3^n$° where m and n are positive integers. Many of these angles could not be constructed by using straight edge and compasses only.

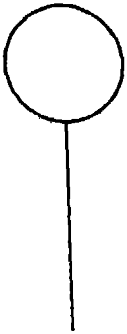

Fig. 4

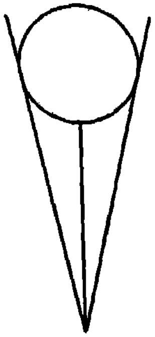

Fig. 5

Constructing a Regular Polygon of nine Sides

The external angle of regular polygon of 9 sides is 40° and an angle of 40° can be obtained by trisecting an angle of 120°, so that a regular polygon of 9 sides can be constructed by using a straight edge, compasses and tomahawk trisector.

In the same way we can construct regular polygons of 18, 36, 72, 144 sides and in general of $2^m 3^n$ sides.

A Tomahawk Bisector

This is shown in Fig. 4. By inserting it in any angle, so that the straight line passes through the vertex of the angle and the two sides of the angle touch the circle, we can divide the angle into two equal parts. Of course we can bisect an angle by using straight edge and compasses only, but this gives an alternative and possibly a simpler method of bisecting an angle.

Similarly consider the quadrisector given in Fig. 6. We can use it to divide an angle into four equal parts in one step only (Fig. 7) while by using straight edge and compasses. We will have to take two steps to divide an angle into four equal parts.

We can also use a tomahawk bisector and a tomahawk trisector to divide an angle into six equal parts.

In fact by using a tomahawk bisector and a tomahawak trisector repeatedly, we can divide any angle into 2^m x 3^m equal parts. We can also use a tomahawk quadrisector to reduce the number of steps.

Of course bisection and quadrisection can also be done by paper folding.

Open Problems

- Can you derive a similar simple instrument to divide an arbitrary angle into 5 or 7 or 11 or in general into p equal parts, where p is a prime > 3 ?
- Can we use an ellipse for any other convex symmetrical figure, instead of circle in a tomahawak trisector ?
- Can we use this figure in a tomahawk bisector or a tomahawk quadrisector ?

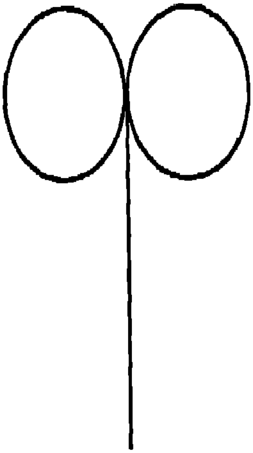

Fig. 6

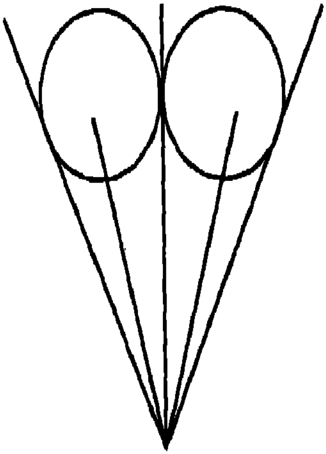

Fig. 7

Recombinant DNA Technology in the Field of Medicine and Human Health

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The discovery of enzymes that could cut the hereditary material DNA (deoxyribonucleic acid) at internal specific sites was an event of great significance as it led to establishing a new branch of science called recombinant DNA (γ-DNA) technology or genetic engineering. Basically, genetic engineering means experimental manipulation of DNA of different or unrelated species producing recombinant DNA that includes some genes from both the species. Recombinant DNA technology, therefore, broadens the possibilities of transferring genes between unrelated organisms and creating novel genetic information by the specific alteration of cloned genes.

The techniques involved in the γ-DNA technology includes cutting DNA into specific fragments using enzymes, called restriction endonucleases, and then joining those fragments with the help of an enzyme called ligase.

Plasmids and viruses can incorporate fragments of foreign or host DNA in their own chromosomes and act as vectors for transfer of genes to closely related bacterial species. These vectors bearing chromosomal genes can either become integrated into the chromosome of the recipient cell or exist as independently replicating units in the cytoplasm.

Recombinant DNA technology has travelled fast in providing material and procedures for gaining insight into molecular processes and mechanisms for practical use in diverse fields including medicine, human health, agriculture and industry. Besides, it has also opened up new opportunities for highly specific manipulation of the genetic material.

Using techniques of γ-DNA technology genetically engineered (or transgenic) plants and animal species have been developed. It has been possible to develop genetically manipulated fast growing crops with better nutritional status, resistance to insects, pests and frost damage etc. Transgenic creatures having non-parental DNA have also been created using the techniques of γ-DNA technology.

Starting from slow-ripening Flavr Savr tomatoes and the γ-BST hormone that enhance milk yield in cows some of the latest advances in the field include a transgenic cow whose milk contains human proteins and allegators that 'manufacture' blood containing human haemoglobin so as to deliver the higher oxygen-carrying capacity required during surgery.

The recent results of γ-DNA technology have revolutionized the fields of medicine and human health. Through genetic engineering of microbial systems it has become possible to develop hormones, vitamins, cytokines, enzymes and antibiotics. Recombinant DNA technology is also being used in the production of monoclonal antibodies (derived from only one clone of a specific hybridoma cell) and for the production of a wide range of vaccines that provide immunization against bacterial, fungal and viral diseases. The technology also finds applications in the development of highly specific diagnostic tests and parental diagnosis of a number of human genetic diseases including phenylketonuria, haemophilia and diabetes.

Some of the genetically engineered phramaceutical products available in the market include human insulin produced by microbes used for controlling diabetes, human growth hormone (HGH) for the treatment of dwarfism caused by pituitary malfunction, tissue plasminogen activator (t-PA) enzyme used against blood clot, human renin for the control of blood pressure, human alpha antitrypsin for the use of patients suffering from emphysema and human interferons (IFNs) used in the treatment of some viral diseases including two rare forms of cancer — hairy cell leukaemia and Kaposis Sarcoma.

Interferons are glycoproteins having molecular weight of about 20,000. They are substances secreted by the infected cells. They belong to the family called cytokines which carry signals locally from one cell to another. As found by scientists, the interferons do not react with the viruses directly. Rather they induce the diseased and their neighbouring cells to make still other proteins that prevent the invading viruses from replicating. Interferons not only inhibit viral replication but also are very important to the proper functioning of the immune system. They are also known to inhibit cell division.

Initially, interferon was thought to be a single molecule. But, it was later discovered to come in various forms. Based on their structure and other properties, interferons have been divided into two main types: Type-I and Type-II. Type-I comprises alpha and beta interferons together with alpha-like omega and tau interferous while falling under Type-II category is solely the gamma interferon. Produced by B- or T- lymphocytes, γ-interferons are reported to be 50 to 100 times more effective than other interferons in destroying tumour cells. The effect of AZT, a drug used to combat HIV, is reported to be enhanced when administered along with the γ-interferon. Some of the Japanese companies have succeeded in producing cloned γ-interferons.

Human insulin (also called humulin) obtained from genetic engineering techniques has been available in the market since 1984. This compares well with the classical insulin obtained from the pancreas of animals. The genetically engineered human insulin is much cheaper as it is produced in large quantities. Also, it is safer as it does not cause the allergic reaction associated with the animal-derived insulins.

Yet another genetically engineered pharmaceutical product is erythopoietin, a protein obtained from transgenic sheep, that stimulates the production of red blood corpuscles. It is used in the treatment of haemophilia and certain types of anaemia.

Erthopoietin was commercially marketed in 1989. However, the molecule is not widely used because of its prohibitory cost. So, scientists have been working toward exploring a gene therapy approach to help the body produce erythopoietin itself.

With the development of a novel technique based on the use of organoids and adenovirus, success in this direction has recently been achieved by Yves Bouzard of the French Institute for Health and Medical Research.

The Bouzard's technique involves taking samples of skin cells, fibroblasts, from a healthy mouse and putting them in a culture plate before infecting them with an adenovirus, where a gene coding erythopoietin synthesis is induced. Once the cells are altered they are locked into a collagen and synthetic fibre mass. The 'neo organ' is then grafted into the peritonea of the same mouse.

The technique results in a significant rise in the number of red blood corpuscles for an average of six weeks. It has a number of noted advantages. In the first place, the safety or efficiency of erythopoietin secretion can be checked before implanting the organoid. Moreover, if needed, the organoid can even be taken out. Also, there is no contaminating free vector liable to infect cells other than the ones handled *ex-vivo* lastly, unlike the retrovirus, the adenovirus when combined with 'neo organs' does not integrate the cell genome. The adenovirus vector does not risk to cause insertion mutations namely the activation of oncogenes or the inactivation of tumour-suppressing genes. However, the problem of immune response triggered by the viral proteins having tendency of destroying the organoid several weeks after the graft, still remains to be tackled and controlled.

Comparative Studies on Sodium Hydroxide and Methanol Extracts of Orange Mesocarp Rutin for Wood Adhesives

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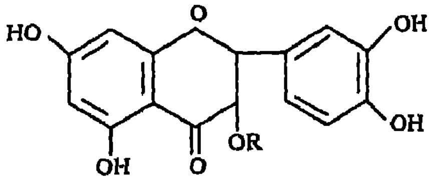
THE increasing demand for wood adhesives world wide and coupled with the extremely high cost of importing these adhesives from the developed nations make it imperative to start a search for alternative sources of raw materials. Of particular note is the fact that phenolic tannins and products based on them, from agricultural wastes have over the years found rewarding industrial outlets, notably in the technology of polymeric resins for coatings and adhesive applications. The use of tannins from agricultural wastes as substitutes for synthetic phenols which have been recognized include wattle bark (Saayman 1974, Pizzi 1978), peanut skin (Randall et al, 1978 and Chen 1982), bagasse (Saad et al, 1978), onion skin (Kumar and Dara 1981 and Odozi 1986, Akaranta et al 1996), and various tree barks (Dalton, 1950, Herrick and Bock 1958, Hellis and Garda, 1959 and Coppens et al 1980) orange mesocarp (Akaranta and Wankasi 1998). No information is available on the comparative studies of sodium hydroxide and methanol extracts of the orange mesocarp rutin for the production of wood adhesives.

Phenolic tannins and products based on them undergo the well-known reactions of phenols with aldhehyde i.e. formaldehyde, furfural. It has been reported that the pulps and peels of orange, grapefruit, lemon, and table grapes contain flavonoids i.e. rutin (Dewart et al 1980 and Buckingham 1982).



R= Rutinose

Experimental

Materials

Orange mesocarp was obtained from Port Harcourt in Rivers state. Wood veneer (Obeche and White steculia) was obtained from African Timber and plywood limited sapele. All chemicals and solvents used were of technical grade unless otherwise specified.

Methods

Rutin Extract with Methanol

The orange mesocarp was sun dried and the particle size reduced using electric blender. Thirty grams of the fine particles were extracted in a soxhlet extractor with 500 cm^3 of methanol as extracting solvent. The yellow extract was concentrated by distilling of the solvent under reduced pressure.

Rutin Extract with Sodium Hydroxide

Twenty five grams of the sun dried and well ground orange mesocarp were extracted with 450 cm^3 of 1% NaOH solution, by heating the beaker and content in a water bath at a temperature of 50°C for 30 minutes. The yellowish extract was filtered through a Buchner funnel.

Preparation of Orange Mesocarp Rutin Resin

RESIN 1 [Orange Mesocarp rutin (Methanol extract)/HCHO/Resorcinol] : 1.2 mole of orange mesocarp rutin (methoanol extract), 1.5 mole of 40% aqueous formaldehyde and 0.9 ml of anti-foaming agent were mixed in a flask at ambient temperature. To this mixture 50 cm^3 50% sodium hydroxide solution were added and refluxed for one hour and cooled. This was followed by the addition of 0.30 mole of resorcinol (in 100 ml distill water) and refluxed for 30 minutes, then cooled and stored.

RESIN 2 [Orange mesocarp rutin (methanol extract)/HCHO/Resocinol] : A mixture of 1.2 mole of orange mesocarp rutin (methanol extract), 0.36 mole of resorcinol (in 200 cm^3 distill water) and 0.9ml of anti-foaming agent were mixed in a flask at ambient temperature. To this was added 1.5 mole of 40% aqueous formaldehyde and 50 cm^3 of 50% sodium hydroxide solution and refluxed in a litre round bottom flask for one hour, cooled and stored.

RESIN 3 [Orange mesocarp rutin (NaOH extract) HCHO/Resorcinol] : 1.2 mole of orange mesocarp rutin (NaOH extract), 1.5 mole of 40% aqueous formaldehyde and 0.9ml of anti-foaming agent were mixed in a flask at ambient temperature. To this mixture 50 cm^3 of 50% sodium hydroxide solution were added and refluxed for one hour and cooled. This was followed by the addition of 0.30 mole of resorcinol (in 100ml distill water) and refluxed for 30 minutes, then cooled and stored.

RESIN 4 (Orange mesocarp rutin (NaOH extract)/HCHO/Resorcinol) : A mixture of 1.2 mole of orange mesocarp rutin (NaOH extract),/0.36 mole of resorcinol (in 200 cm^3 distill water) and 0.9ml of anti-foaming agent was prepared at ambient temperature. To this was added 1.5 mole of 40% aqueous formaldehyde and 50 cm^3 of 50% sodium hydroxide solution and refluxed in a litre round bottom flask for one hour, cooled and stored.

Formulation of Glue Mixes

The orange mesocarp rutin glues were prepared by mixing together (parts by weight) 100 resin, and 16 paraformaldehyde (98%). Water was added to bring the pH to between 8 and 9. This was followed by the addition to carboxy-methy-cellulose (CMC) to adjust the viscosity to between 20 and 25 poises.

Evaluation of Resin and Glue

The hot plate gel time of resins were determined with a Tecan gelation timer. The per cent solid contents of resins were determined by the method commonly used at African Timber and plywood (A.T&P), sapele. The pH measurement was taken with E/L 7050 pH meter.

The pot-lives of the glues were obtained by the method of Tiedeman and Sanclemente (1973).

The physical appearance of resins was determined with a colorimeter.

Veneer and Plywood Production

Commercial sapele wood veneers (white sterculia or sterculia oblonga and obeche or triploefriton scleroxylon) with 1.2mm and 4mm thickness respectively were obtained from African Timber and plywood Limited sapele. Prior to usage in the plywood production, the veneers were cut into 30.48 cm × 30.48 cm sheet sizes and the moisture content of veneer was 6.0%.

The glue mixes were applied and the plies bonded using a hot press of 100-110°C for 5 minutes at a specific pressure of 10kg/ cm^2. The panel were left to stand overnight to allow bond equilibration.

Thereafter the panels were cut into 14.1 cm by 9.6 cm strips each for the dry knifing test, 8 cm by 8 cm for moisture content test, 9.0 cm by 3.8 cm strips for shear strength determination, 24.2 cm by 5 cm for bending strength determination and the 24 hours cold soak and 6 hours boil tests.

Evaluation of Bond Quality

Shear strengths, bending strengths and wood failures were obtained using Masanto Tensometer Type W. The dry bond, boil, cold soak and moisture ratings were determined by the methods of African Timber and Plywood Limited Sapele.

Results and Discussion

Characteristics of Resins

Table 1 lists the gel times, per cent solid content, pH, physical appearance and pot lives of the resins. Gel time is a measure of reactivity of the resins (Odozi, 1986) and is shown to be high for resins 1 and 4, indicating high temperature input if an industrially meaningful press time is to be achieved. Resins 2 and 3 have high per cent solid content and would be expected to have higher molecular weights.

Low pH gives poor bond strengths and wood failure results, while high pH considerably shortens the adhesive pot life (Pizzi 1979). Table 1 shows that all resins have moderate pH values. Moderate pH values are needed to enable the curing agent (paraformaldehyde) to unzip in order to cause crosslinking.

Colour change is an indication that a chemical reaction has occurred. The

Table 1
Characteristic of Orange Mesocarp Rutin Resins

	Resin 1	Resin 2	Resin 3	Resin 4
Gel time (s)	60	48	46	62
Per cent solid content	22.5	50	50	25
pH	11.6	11.7	11.7	11.6
Physical appearance	Dark red	Dark red	Black	Red brick
Pot life (glue) h	3.80^a 0.65^b	36.60^a 0.70^b	3.79^a 0.63^b	2.60^a 0.55^b

a= at room temperature — 28°C; b = at elevated temperature — 60°c.

essence of recording the physical appearance of the resin is to see if any reaction had taken place on storage. The potlife of resin 4 is shorter than the rest. Much longer potlife is conducive to much poorer results (bond quality) and much shorter potlife would be industrially unrealistic. BS 1203 (1963) specification for phenolic adhesive resins requires a working life in the range of 1-24h, and all the adhesive resins in Table 1 satisfy this requirement.

Bond Quality in Veneer Plywood

The adhesive quality results in Table 2 show that sodium hydroxide solution extract of the orange mesocarp rutin performed better than those of methanol extracts. This is due to the slow evaporation of the methanol from the gluelines with consequent glueline drying.

All glue mixes formed suitable bond on hot pressing. The shear strength and wood failure values reported in Table 2 show that all resins satisfy the require-

Table 2
Bond Qualities of Glue Mixes

	Resin 1	Resin 2	Resin 3	Resin 4
Shear strength (kgcm^{-2})	12.70(24.49)	11.79(24.49)	12.80(24.49)	22.0(24.49)
Bending strength (kgcm^{-2})	23.59(24.95)	18.14(24.95)	19.05(24.95)	18.14(24.95)
Wood failure (%)	10(30)	30(30)	40(30)	50(30)
Dry knife rating	2^a 2^b (8)	2^a 2^b (8)	6^a 6^b (8)	6^a 6^b (8)
Cold soak	2^a 2^b (6)	2^a 2^b (6)	4^a 4^b (6)	4^a 4^b (6)
6h boil	0^a 0^b (6)	0^a 0^b (6)	2^a 2^b (6)	2^a 2^b (6)
Moisture content (%)	13.8(11.3)	11.3(11.3)	12.4(11.3)	10.8(11.3)

( ) Control, a = face 1 of plywood, b = face 2 of plywood ments of the modern SAB specification in which percentage wood failure plays a more important role. The bending strength test signifies the load plywood can withstand when used as crossbars in cupboards or similar material. All resins gave encouraging results.

The knife test was evaluated in terms of British standard BS1088 as reported by Pizzi (1978). The knife values as shown in Table 2 indicate that resins 3 and 4 have high knife ratings thus satisfying the British standard 1455 as reported by Wagner (1982). The low performance of resins 1 and 2 may be attributed to the slow evaporation of the methanol from the glueline.

The cold soak results show that glues 3 and 4 produced from the sodium hydroxide extract gave good rating values while resins 1 and 2 produced from methanol had average rating values. Also plywood samples subjected to the boil test failed predominantly in the glue for resins 1 and 2. The inability of resins 1 and 2 to resist the water boil proof (WBP) test showed that they can only be used as interior grade plywood. The resins 3 and 4 produced from the sodium hydroxide extract gave average rating values.

All the moisture content values shown in Table 2 are within specification for optimum performance (in terms of adhesion) as reported by Wagner (1980).

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Miniature Power Pack for Mobile Services*

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The trend in battery development is moving inexorably in the direction of smaller, lighter units which are more powerful, reliable and flexible. The requirements are, however, extremely diverse, depending on whether they are to be used in a notebook computer, mobile phone, heart pacemaker or chip card. The power required varies from a few milliwatts to 100 watts, operating lifetime from a few hours, or up to 10 years. The devices range from expensive Internet-enabled multimedia terminals through to ultra-thin disposable electronic products such as smart labels or intelligent sticking plasters. For the new generation of mobile devices all components will have to be miniaturised and optimally integrated in a total system. The key requirements for this are energy-saving electronics and an integrated energy supply. "On their own, the small and medium-sized firms which up to now did most to develop these products can no longer afford the massive advance in innovation which is now required", is how Joachim Pelka summarises the result of a study undertaken by the Fraunhofer-Group Micro-electronics. The Fraunhofer Gesellschaft has identified this area as one of strategic importance.

Project co-ordinator Dr Gunther Rohmer from the Fraunhofer Institute for Integrated Circuits (IIS) says: "This requires interdisciplinary co-operation in the fields of semiconductor and component technology, electrochemistry, solid-state ion research physics, polymer research, and assembly and interconnection technology". This is the advantage enjoyed by the Fraunhofer-Group involving various Fraunhofer institutes, as it can draw focus on common goals. Three terminals are being developed as demonstration units: a multimedia player, a sensor wrist strap with foil battery and a tire pressure sensor incorporating wireless information transmission which draws its energy from the rotation of the wheels.

In all new units energy management plays a central role because the energy supply increasingly represents an interplay of many different components: energy storage cell, power and battery management, load management and distributed intelligent components in almost all the assemblies that make up the terminal. The other key requirement is a new generation of rechargeable batteries. In mobile applications, thin-film batteries are of particular interest because they possess the ideal characteristics for integration. Developments in smart cards alone entail a great

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market potential because soon 20 percent of chip cards will run on batteries.

Power from Thin, Flexible Foils

A whole host of different accumulator types already exist; Nickel-cadmium nickel-metal-hydride (NiMH), alkaline manganese cells and lithium systems offer a broad spectrum of performance quality and price. To date, however they have not been able to overcome their disadvantages — too heavy, too big, too expensive, inadequate service life.

World-wide, lithium accumulators are regarded as the most promising candidates for supplying energy to the next generation of portable information and communication systems, because they possess the highest energy densities of all the rechargeable battery types.

For the first time anywhere in the world, the Fraunhofer Institute for Silicon Technology (ISIT) has succeeded in proving that high-performance solid-electrolyte foil accumulators can be produced which are light in weight, environmentally friendly and inexpensive. The major breakthrough achieved by the ISIT accumulator is its ease of manufacture, because only unproblematic materials that are easy to process are used. The basis for each individual foil layer is a paste which is produced from a powder mixture of polymer electrode or electrolyte material and solvent. The cell is only 0.5 to 1 millimetre thick and adaptable in surface area. The flexible cells can be shaped as required, rolled, stacked to form flat, cuboid or cylindrical packages. This amenability to shaping is a key requirement for the space-saving design of modern mobile communication devices.

Laboratory Cell Attain High Energy Density

The ISIT in Itzehoe has already installed a complete laboratory production line and deployed an industrial standard accumulator tester so that it can produce sample series. The institute is currently supporting a young business start-up whose prime goal is to install a pilot line to handle the industrial production of accumulators for use in mobile communications. Potential for the foil accumulators is also opening up in smart card/smart labels and in medical engineering.

In parallel, the Fraunhofer-Group Microelectronics is developing a wider-ranging battery concept to cover differing performance ranges and applications. One of its aim is to develop not only foil batteries but also structured thin-film batteries. The main advantage of the alliance is that all intellectual property rights for developments in battery technology by the Fraunhofer institutes and their external project partners will be assured through patents.

At present, the development of mini and micro fuel cells for portable electronic devices in the extremely low power range is still in its infancy. Fuel cells typically produce electricity through the reaction of hydrogen with oxygen. One design of a mini fuel cell is based on a strip membrane concept developed by the Fraunhofer Institute for Solar Energy Systems (ISE) which permits a very flat design. For applications with low output voltages they developed a highly efficient DC/DC transformer which functions with input voltages as low as 0.55 V. The combination of the fuel cell with a direct current transformer enables the voltage to be adapted to various electronic consumers. The prototype, which has a diameter or just 144 mm, a height of 20 mm and weighs 500 grams, meets these requirements.

This system can deliver up to 50 watts, enough to power small devices including laptops and camcorders. Such micro fuel cells are intended to one day provide the power supply for palmtops, personal organisers, hand-held electronic games and other small devices.

Concept Learning in Science

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SCIENCE, in order to tell anything about the world must contain empirical elements. This is so because information about the world is received by experience alone. Perception, therefore, is fundamental to all science. It is this empirical component which basically differentiates science from fantasy. Science being a social enterprise data available in it are shared, ideas exchanged and experiments replicated. It is precisely the culmination of empirical evidence which shapes a welter of diverse opinions into scientific knowledge common to many minds (Kaplan, 1980).

Semantic empiricism states that not only knowledge but even meaning is dependent on experience. A proposition to be meaningful must be capable of being brought into relation with experience as a test of its truth. But most scientific concepts, particularly the theoretical ones relate to experience only indirectly. The meaning of a scientific concept is scientifically valid only if what scientists intend by it becomes actual i.e. problems are solved and intentions are fulfiled as enquiry continues.

Concepts and its Formation

A conception belongs to a particular person. However, more than one person may have similar conceptions. In general, conceptions differ from time to time. For example conception of an atom to a child will be different from that of a nuclear physicist. It may again differ from what it was before, once the child matures and becomes aware of nuclear reactions.

The term 'concept' is a construct or a theoretical term which is impersonal and timeless. Teaching and learning are endlessly concerned with the development of concepts. In the process of teaching the teacher realises that some tasks are easier than others. Also it is he/she who has to decide — which concepts to teach now and which to leave until the children are older. Age, of course does make a difference.

The difficulty of a concept depends on whether it is conjunctive or disjunctive. Typically, conjunctive concepts are easier to learn. While dealing with disjunctive concepts however, a new attribute may open the door to a whole new group of members. Some conjunctive concepts are easier than others. Younger children easily master a concept of concrete object like dog or car than say geometrical forms like square or rectangle. Geometrical forms, in turn, are easier than abstract numerical concepts like twice, half etc.

How to go about teaching a given concept difficult or easy to a group of students—young or old ? Alternatively, what psychological principles or pedagogical information can be used to aid in the task ? Researches and experiments conducted to date indicate that there should be a rich diet of reinforcement especially in the early stages. Each successful response should be confirmed and acknowledged. Some concepts may be taught particularly to older students by exposition, deduction or taught inductively by means of examples and illustrations. Experiments suggest that better results are obtained if positive examples are presented first omitting negative examples. Some other pertinent questions in this context are (a) what is concept ? (b) are all concepts similar ? (c) are they formed in the same manner ? Experiments by Ach (1921) illustrated that concept formation is an active, creative process and not merely a passive reception of obvious association. For Ach, the critical element in concept formation is a "determining tendency" which is the individual's image of the goal.

Steps in Concept Formation

Concepts are learned more efficiently by proceeding from simple to complex. A combination of abstract and concrete examples result in greater functional efficiency than use of either alone. Vygotsky, based on his studies of more than 300 children—adolescents and adults concluded that concept formation occurs in the following three basic steps :

- ☐ A syncretic form of thinking
- ☐ A complex form of thinking
- ☐ The formation of potential or true concepts.

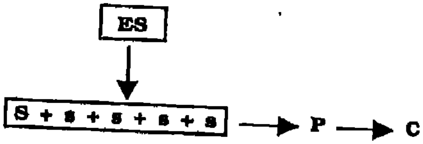
The first step in concept formation occurs when children group without any basis a number of desperate objects. They thus unite diverse elements into one articulated image because of some chance impressions (Vygotsky, 1962). In the second step individual objects are combined in the child's mind not only by personal chance selection but because of bonds actually existing between these objects. Thus while syncretic thinking depends upon purely subjective bonds; complex thinking depends upon actual similarities or perceptual bonds between objects. Finally, in potential concepts single traits are abstracted. The true concept appears when abstracted traits are synthesised and these abstracted syntheses become the chief instrument of thought. Vygotsky summarises his study by stating that the processes that result in concept formation begin in earliest childhood, but that the intellectual functions necessary for concept formation develop and ripen only at puberty.

Klausmeir and his associates recognised that the ability of children to acquire concepts depends on both external (appropriate instruction) and internal conditions (maturation and learning). The Conceptual Learning and Development model traces concept attainment through four successively higher levels namely concrete, identity, classificatory and formal. These four levels emerge in an invariant sequence i.e. children exhibit a distinct developmental trend in concept acquisition. Klausmeir and his colleagues further observed that the attainment of a particular concept varies among children of the same age. For example it was found that 17 per cent of the Class III children attained equilateral triangle at the formal level but 83 per cent did not. The same children acquire different concepts at different rates e.g. 30 per cent of the Class IX children attained 'noun' at the formal level, while 90 per cent attained 'cutting tool' at the formal level.

Conditions Influencing Concept Attainment

Environmental conditions influence concept attainment. Klausmeir states that instructional conditions can facilitate conceptual development. Instruction therefore, must match conceptual level. Initially the teacher identifies those concepts that students are to learn in a subject. He/she should then decide at what level each of the students should attain them. Fear, anxiety, habit and inexperience, either singularly or combined all produce conceptual blocks.

When environmental stimuli contact the individual they initiate the process of concept formation. Sensation is the first step in this process. If sensations are vague, distorted or inaccurate the concepts formed will likewise be vague, distorted and inaccurate. Further, we react to some stimuli and not all. This is because — (a) some stimuli demand our attention, (b) we want to react to certain stimuli frequently due to motivation or readiness and associate pleasure with it. If a person is sufficiently mature the visual symbol alone will arouse the concept. He/she forms mental representations or objects, things, people and events even when they are not present.



ES - **Environmental Stimuli**
S - **Present Sensation**
s - **Past Sensations**
P - **Perception**
C - **Concept**

A person imposes order wherever he can — identifying familiar, orderly patterns. He/she imposes the pattern even where it fits poorly. In any complex display the experienced person looks for the chief sections, the dominant elements, the lines of force of linkage. All the while however, it is important to remember that concepts misrepresent realities, exaggerating similarities and differences just as perceptual patterns do. Each concept is created by the individual from his own experience. Thus a concept is at first impressionistic. Most of our every day non-technical concepts are left in this primitive stage. In one sense, a person has attained a concept when he/she is able to discriminate the situations to which it does apply from all the rest. Discrimination is only a part of concept development, but it is a critical part.

Teaching-Learning of Concepts

Concepts are only as valuable as the meaning they convey. In order to teach concepts effectively in science the teacher should define, give examples and explain; provide varied learning experiences so that the learner sees, feels and talks about it. In other words the learner uses as many senses as possible. A new concept should be presented using assorted methods, different techniques or employing a combination of methods. The teacher encourages self activity on the part of the learner so that he/she is able to apply the concept in familiar situations. Learning gets facilitated when the situation satisfies a need or purpose of the learner making the situation meaningful to the child. The concept should be suitable to the maturation level of the learner and is made interesting by giving rewards, providing favourable physical conditions or increasing number of associations.

Uniqueness of the child, needs, self concept and readiness, place of extra-sensory perceptions, methods of teaching for optimal learning, self activity and variety of experiences, intellectual development, appropriate instruction, maturation and environmental conditions, conceptual learning blocks are just a few issues in this context which require careful research and experimentation to give suitable directions for productive science learning.

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Value of Mathematics Education

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THE MATHEMATICIAN, carried along on this flood of symbols, dealing apparently with purely formal truths, may still reach results of endless importance for our description of the physical universe" - Kearl Rearson.

There is no aspect of life which is not permeated by mathematics and the world of today can not be intelligently understood by a citizen who does not posses knowledge of mathematics. From concrete beginning, it has passed through the stages of commercial and social uses to build up the civilisation of today and there can be no question of teaching mathematics of pupils without emphasis on the use and applications of mathematics. Social, commercial and technical applications of mathematics are no doubt highly useful and valuable forming the core of mathematics education.

Now-a-days, value of mathematics education has increased considerably because of its applicabilities in diverse field of human activities pertaining to industrial, demographic, socio-economic planning and management, geographical surveying, scientific, technological, environmental, biological, medical and hygienic problems etc. In fact, mathematics has the scope of its application whenever there are data and interventions of different variables/constraints/parameters to model the situation. While grappling with data based problems, a mathematician first looks for certain trend, physical, scientific or commercial laws which enable him in formulating the pertinent hypothesis conducive to the entire scenario or the framework of the problem in consistence with the specific objectives to be attained. Secondly, he identifies variables involved and tries to explore relationships between them. Thirdly, through proper symbolisation, he translates relationships into mathematical equations and finally solve them using algebraic or numerical technique. After having obtained the mathematical solutions, mathematician interprets solution in terms of original problem and compares the result with hypotheses and real observations. If these are found in agreement, the model is accepted otherwise hypotheses are rectified or modified suitably and the process is repeated until and unless appropriate solution of the problem is evolved. This is what we call mathematical modelling.

Mathematics like music and poetry is the creation of mind, the primary task of mathematics education is to extend mental horizon by representation and interpretation. Darwin said, "Every new body of discovery is mathematical in form". Mathematics provides, a convenient and accurate method of summarizing experience, for without some compactification device or formula, it would be impossible for the mind individual to grasp the complicated pattern revealed by laboratory experiments. The mathematical formula is another way of expressing or communicating about all knowledge gained by practice, experiments and observations and perhaps then only can it be scientifically grasped.

Mathematics, above all other subjects, makes the student lust for knowledge, fills him with a longing to fathom cause of events and to employ his own powers independently, it focusses faculties and concentrate them on a single point and thus awakens the spirit of individual enquiry, self-confidence and joy of doing it. Mathematical studies are of immense benefit to student by habituating him to precision. In fact, definiteness of the subject is commonly admitted. Mathematics as an instrument of education strengthens the power of attention, develops the sense of order and faculty of construction and enables the mind to grasp the quantitative differences of physical phenomena. The motive for the study of mathematics is insight into the nature of universe and to develop observation, imagination and reason. The training which mathematics gives in working with symbols is an excellent preparation for other sciences.

The knowledge of mathematics proceeds from concrete to abstract under the systematic framework constituted by postulates, definitions, premises, logical connectives and rules. These provide an axiomatic basis to mathematics for carrying out deductions and generalisation attributing rigour to it. Constant drilling of mental process along such mathematical process tend to settle a certain type of mental discipline wherein consistencies, precision, accuracies and definiteness become the hallmark.

It is fascinating to mention that mathematics through its power of deductive process encompassing axiomatic framework lifts us beyond human experiences. For completeness it is worth mentioning a simple and powerful principle of mathematical induction which when applied to a conjecture or statement P(n) (say) where n runs over infinite set of natural numbers. The accuracy of the statement just for $n = 1$ and the assumption of its validity for any natural numbers k resulting in its veracity for the next successive stage $k + 1$ ensures the authenticity of the statement for all natural numbers. Here, it is interesting to note that the principle in itself contains the validity of the statement where infinite process gets automatically assimilated and revealed. Otherwise, it would be quite arduous, cumbersome rather impossible for any one to go on checking the conclusion infinitely many times. This illustration depicts implicit powers of mathematics in revealing the infinite process within the range of manipulation and comprehension. Laplace, one of the greatest physicists and mathematicians, commenting on this principle remarked, "Analysis and natural philosophy owe their most important discoveries to this fruitful means, which is called induction. Newton was indebted to it for his theorem of the binomial and principle of universal gravity".

For optimal realisation of values generated by mathematics, its curriculum has to be structured and transacted as guided by three basic prerequisites through the integrated approach at each stage. The following integrations should be ensured in the curriculum during the entire span of teaching of mathematics :

- ☐ Integration amongst various topics of mathematics
- ☐ Integration of mathematics with allied subjects
- ☐ Integration of mathematics with real life situations.

Besides incorporating above cited components, textbooks prescribed for a particular stage must be supplemented with adequate illustrations of underlying concepts, correlating these with different fields of experiences, interwoven with sequential and historical development of the topics indicating inherent and implicit values of these topics conducive to the social, economic, scientific and technological concerns and aspirations so as to cultivate in the learner healthy attitude and scholastic aptitude resulting in the appreciation of real Intrinsic Value of Mathematics Education.

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Attitudinal Objectives in the Chemistry Curriculum

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THERE ARE three kinds of objectives that chemistry teachers should emphasize in the curriculum. The most common kind of objectives stressed are knowledge ends. Knowledge pertains to facts, concepts, and generalizations emphasized in ongoing units of study. In these units of study, if pupils learn inductively and/or deductively that there are three states of matter — solids, liquids and gases — a fact has been learned. All content needs to be learned in a meaningful manner such as pupils noticing in an experiment that raising the temperature to an appropriate level, ice as a solid changes to water, a liquid. Further appropriate raising of the temperature change the water to steam, a gas. A variety of concrete (experiments, demonstrations, use of objects and items, as well as realia), semiconcrete (videotapes, illustrations, filmstrips, films slides and CD-ROMS), as well as abstract (listening, speaking, reading and writing) learning activities assist the student in depth understanding of the original fact acquired.

Concepts emphasize relevant single words or phrases as objectives for students to achieve. The *concept* of physical properties of a substance may be analyzed in terms of hardness, colour, density, boiling point, melting point and thermal or electric conductivities. When physical conditions change such as temperature, then water changes to solids or liquids. Chemical properties change when substances undergo chemical reactions. In context within an ongoing unit of study, pupils may learn the generalization. "The metal called magnesium combined with oxygen, a colourless gas, forms magnesium oxide, a white solid." There are numerous concepts in this *generalization*, such as metal, magnesium oxygen, gas, magnesium oxide, and solid. A generalization consists of related facts in a declarative sentence. Each concept is unique and increasingly complex to understand, unless meaning theory is stressed whereby a variety of learning opportunities are used sequentially to guide student understanding of the generalization. Vital facts, concepts, and generalizations become important objectives for pupils to achieve. If learners do not understand a major generalization, the chemistry teacher needs to teach the related concepts therein., If concepts are not understood, then relationship of facts needs to be taught in a meaningful way. Memorization is not to be encouraged, but rather pupils should understand knowledge that is stated within each objective to be achieved. A variety of learning opportunities, starting with concrete activities, followed by the semiconcrete, and then the abstract should assist students to experience a sequence which might guide more optimal achievement.

In addition to knowledge objectives, the student also needs to achieve vital *skills* such as those involved in problem solving. Chemists in a laboratory setting, identify vital problems. Information from a variety of sources need to be obtained in answer to the problem. A tentative hypothesis is developed which needs testing. The hypothesis may need redoing or modifying as a result of testing. Critical and creative thoughts are inherent within the problem solving experience. Critical thinking analyzes facts from opinions, reality from fantasy, as well as the relevant from the irrelevant. Creative thinking stresses the novel and the unique. Thus, the same approach used in problem solving may not always work, but a creative mind can overcome difficulties. Also, in identifying problems, the creative mind perceives gaps in information and desires to obtain knowledge to bridge the gap.

The third kind of objective to emphasize in teaching chemistry is the attitudinal end. Why are good attitudes of utmost importance in teaching and learning in chemistry ? Quality attitudes can assist pupils to achieve subject matter more effectively. Quality attitudes indicate that a learner has an inward desire to learn. This inward desire to learn is vital in chemistry.

Developing Positive Attitudes in Chemistry

I have just appraised a Ph.D thesis entitled *Chemistry Curricular Potentials of Chemical-Based Industries* (1998) for Madurai Kamaraj University, Aruppukottai, India. The author of the Ph.D thesis is very strong in making the following recommendations —

1. Pupils seeing the relationship between the classroom and what transpires at the work place. Too frequently, what is learned in chemistry in the classroom has no perceived relationship in terms of how the knowledge is to be used.
2. Theory and practice being related to each other, and not being separate entities. A hands on approach needs to be emphasized in teaching chemistry whereby an abstract theory is related to the utilitarian or hands on approaches in learning in chemistry.
3. Excursions to chemically based industries motivates learners and varies the kinds of learning opportunities provided.
4. Memorizing content without understanding makes for a lack of interest in learning on the part of students.
5. Learner based instruction needs to be emphasized in the chemistry curriculum. An adult-centred curriculum does not meet the needs of students in chemistry.

Pupils need to perceive the chemistry curriculum as being valuable presently as well as for the future. Knowledge acquired in ongoing units of study might then have application values. What has been learned can then be used and not learned for its own sake only. Students too frequently feel there is little value in acquiring what is being taught in chemistry in the classroom. However, with perceived application values. Students do feel increased purpose or reasons for learning. Comprehension of content is vital before application can be made. Rote learning of subject matter might well provide difficulties to students in using what has been learned. Hands on approaches in teaching chemistry assists students to comprehend and thus make knowledge more usable. More positive attitudes are then an end result also.

There are attitudinal problems toward chemistry that keep students from achieving relevant objectives. Thus, positive attitudes need to be developed by having a learning environment which fosters a warm and relaxed atmosphere whereby students feel accepted and are willing to take risks in achieving complex objectives. Anxious, nervous students in ongoing chemistry lessons and units of study will hardly achieve optimally. Comprehension of subject matter in these cases will be minimized. Students' attitudes toward learning will be affected by feeling of success and active involvement and not being a passive recipient of knowledge. An end result might well be academic growth. The knowledge facet of objectives and their achievement is definitely affected by the attitudinal dimension (Morales-Jones, 1998).

Ediger and Rao (1996) stress the importance of having a variety of learning active so that students might achieve objectives more optimally. Why should there be a variety of learning opportunities in the ongoing chemistry curriculum ?

1. Students have different learning styles, e.g. some learn better on an individual basis as compared to others who desire to be working within a committee setting.
2. Students are at different achievement levels in chemistry and individual differences need to be provided for. Since students individually are achieving at a variety of levels, the chemistry teacher needs to include teaching strategies effective for each level of attainment.
3. Not all students benefit from the same kind of learning activity. The chemistry teacher needs to consider conditions and experiences under which each student may learn as much as possible.
4. Teachers have different teaching styles. The style stressed needs to emphasize a learner centred chemistry curriculum. The focal point is the student when planning for instruction in chemistry.
5. Selected activities capture student's interests more than do others. Interest is a powerful factor in devising strategies for teaching students.
6. Individuals desire new experiences. Sameness and routiness in learning opportunities might well hinder developing learner interests in the chemistry curriculum.
7. Monotony in learning activities hinders students in developing motivation for achieving objectives in chemistry.

Ediger (1995) indicates what his student teachers and cooperating teachers, whom he has supervised in the public schools, have advocated to develop good attitudes in students toward learning.

1. Assist students to become actively involved in learning. Thus, in the chemistry laboratory encourage students individually and in committees to pursue, grow, and develop.
2. Show a caring attitude toward each student. No student should fall between the cracks. If a student does not understand what is taught, take time to make certain that meaning in learning is being achieved in the ongoing presentation.
3. Accept each student as having extreme worth and deserving respect.
4. Provide a learning environment for chemistry which is conducive to meeting student needs.
5. Recognize student capabilities and achievements so that esteem needs are being met.
6. Provide a challenging environment whereby students are motivated to attain as optimally as possible.

The Psychology of Learning and Chemistry

To assist students to achieve knowledge, skills and attitudinal objectives as well as possible, the chemistry teacher needs to apply selected theories of learning in unit teaching. The student needs to possess adequate background information in order to understand what will be taught when initiating a new unit of study. The background information then provides readiness for students to actively achieve relevant new objectives in the chemistry curriculum. Second, the sequence of learning opportunities which follow must guide studies to make continuous optimal progress. The order of activities and experiences which follow in teaching harmonize with each student's highest possibilities for achievement. Third, the learner should be able to reveal what has been learned through additional means, other than paper/pencil testing largely/only. These additional approaches in indicating what has been learned include performing experiments, demonstrations, construction activities, project methods and problem solving experiences. The Theory of Multiple Intelligences (Gardner, 1995) indicates that students need to have opportunities to reveal what has been learned through the personal intelligence possessed by the involved learner. Success in learning in chemistry might then be an end result.

Constructivism, as a philosophy of teaching and evaluation, has rather recently received considerable attention as a way of education. With constructivism, the chemistry teacher appraises learner achievement in context, rather than having an outside source such as standardized tests determine what a student has learned. A student individually also should be involved in evaluating the self. With evaluation being done in a contextual situation, the student is given assistance as needed at the moment the help is needed. Guidance is provided to learners on a continual basis in context, rather than once or twice a year as was true of giving standardized tests. One facet of constructivism pertains to portfolio development. Here, the student with teacher assistance develops a collection of purposeful materials to reveal what has been learned. These materials pertain to artifacts of the everyday work of the involved student. There are numerous items that may show representative achievement of a student. The following items are provided as examples of what can become a part of a learner's portfolio —

1. Dated diary entries to indicate what was learned on a daily basis in chemistry.
2. Written summaries of experiments and demonstrations performed in an ongoing unit in chemistry.
3. Recognized achievements or rewards received in chemistry.
4. Logs kept on a weekly basis of what was accomplished in chemistry.
5. Records kept on diverse media used in the classroom such as videotapes, computer disks, word processing, CD-ROMS and other visual aids.
6. Progress reports issued to parents informing of personal progress in chemistry.
7. Committee progress reports.
8. Excursions into the community to link school and society.
9. Work completed at enrichment centres in the classroom.
10. Bulletin board ideas developed and displayed in the classroom.

Additional items that may be included in a portfolio include snapshots of projects completed, research papers, completed self appraisal instruments, simulations, contracts in progress or completed, and theme studies being worked on or finished. The above named items may be placed in a notebook or developed into an electronic CD-ROM portfolio.

Conclusion

Students need to experience an exciting challenging chemistry curriculum knowledge, skills and attitudinal objectives need to be carefully chosen so that what is worthwhile is selected for student learning. Learning opportunities need to be sequential based on readiness for learning. Attitudinal objectives are vital for students to achieve since they assist learners to attain knowledge and skills objectives more thoroughly. A variety of activities needs to be in the offing so that students achieve vital objectives in the chemistry curriculum. Caring teachers who desire to assist each student to attain as optimally as possible are important and necessary. Humanness involving respect for all and high achievement from each student is a challenge and an ideal for chemistry teachers to achieve. Students individually have talents and intelligences which need to be recognized in ongoing learning opportunities as well as in the evaluation process. Portfolio development assists students individually to reflect upon their work in chemistry and work for continuous progress. Portfolio results may be shared with parents, administrators, and guidance counsellors who are interested in helping students individually learn as much as possible in chemistry (Ediger, 1997).

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Study of Achievement Level of Class XI Students in Chemistry — *Aliphatic Hydrocarbons*

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THE 10+2+3 pattern of education has now been accepted throughout the country (NCERT, 2000; MHRD, 1986). The syllabi in different subjects at various levels have undergone drastic change. The syllabus of chemistry at +2 stage has also been modified to keep in pace with the developed countries (Raina, 1999; UNESCO, 1998) and the textbooks have also been rewritten accordingly. Previously, chemistry in general and of carbon compounds in particular, used to be considered as a subject for cramming (Chandra, 2000). Many standardised examinations focussed their attention on computational skill and recall of definitions (Ebel and Robert, 1999; Gupta, 2000). But now a large number of concepts based upon understanding and application of knowledge have found prominent place in chemistry curriculum at +2 stage. Electronic configuraion of elements in terms of s,p,d and f orbitals; why and how of molecules (reaction mechanism); and periodicity in properties in terms of electronic configuraiton are some of the topics which have now been included in the syllabus at Senior Secondary Stage (NCERT, 1999). The improvement of curriculum has changed the thinking both of teachers and students (Rajput, 2000; Tilak, 1999). The present study was undertaken in order to test how the students at +2 stage perform and what type of mistakes they commit in various concepts mainly based upon knowledge, understanding and application of concepts. This paper deals with the performance of students of both sexes in different concepts related to Aliphatic Hydrocarbons. A comparison of achievement of students of different schools in different test items has also been presented.

Objectives

The present study has been carried out with the following objectives —

- To assess the overall difference in the performance of students of different schools, viz., Private management, aided, public and Govt. Schools;
- To compare the performance of boys in knowledge, understanding and application type test items;
- To compare the performance of girls in knowledge, understanding and application type test items, and
- To compare the performance of boys and girls in each of the three abilities i.e., knowledge, understanding and application.

Hypotheses

The following hypotheses have been assumed for the present study :

i. The performance of students of Government schools is poorer than that of other schools.
ii. The overall performance of female students is better than the male students.
iii. Students are far better in knowledge type test items than understanding and application type items.
iv. The male students fare better than females in items based upon understanding and application.

Sample

The sample consisted of 136 male and 65 female students of Class XI of five different school, viz., (i) Private management run school 'A' (10 males and 15 females); (ii) State Govt. run model school — 'B' (34 males); (iii) Public School — 'C' (68 males and 17 females); (iv) Missionaries run Convent School in tribal area—Bastar district of Madhya Pradesh — 'D' (25 females); and (v) NCERT run Demonstration School — 'E' (24 males and 8 females). The sample schools were homogeneous in terms of chemistry syllabus, duration of teaching, method of teaching and teacher competancy. All the students were of English medium co-educational schools. The average age of male students was 16.7 and that of female students was 16.9 years. The average percentage of marks secured in Class X public examination by the male students was 70.0 and that of female students was found to be 73.0. The school-wise average age of students and the average marks secured in Class X public examination are given in Table 1.

Methodology

After careful analysis of the topics 'Alkanes', 'Alkenes' and 'Alkynes' from various textbooks of M.P. State Board, Central Board of Secondary Education (NCERT, 1999) and a few other standard textbooks (Morrison and Boyd, 1999; Jain, 1999), the following concepts were identified.

(a) Structures and shapes of hydrocarbons
(b) Formation of sigma (σ) and Pi (π) bonds
(c) Empirical formula determination
(d) Cause of difference in boiling points of different hydrocarbons
(e) Isomerism in hydrocarbons
(f) Cause of acidic nature of hydrogen atoms in alkynes
(g) Addition reactions of alkenes and alkynes
(h) Determination of oxidation number of carbon in hydrocarbons
(i) Formation of free radicals, carbonium ion and carbanion.

Based upon the above concepts, 30 multiple choice type test items on alkanes, alkenes and alkynes were developed and are given under the title, 'Tools'. The students of all the schools were given an advance notice of 7 days to prepare the topics for the test. Time given for 30 test items was 30 minutes.

Tools

Based upon the concepts and subconcepts from the topics of alkanes, alkenes and alkynes as given in methodology, 30 test items were prepared. All the test items were of multiple choice type having four alternatives with one correct response. Only one test item/ No. 7 was having two correct responses. Out of 30 test items, 13 were of knowledge type, (K); 10 of understanding type (U) and 7 items were kept to test application (A) domain of the students.

The cyclostyled typed test items were administered to the students by the investigator in person along with the subject teacher of the concerned school. The students were asked to encircle the correct response. The time given was 30 minutes. The tool consisting of 30 items is given in Annexure 1.

Analysis

For assessing the performance of students, each test item has been given one mark. Negative marking for the wrong answers has not been done. Thus the test consists of 30 marks and score of each student has been determined out of 30 marks. The data have been pooled itemwise and schoolwise. Itemwise percentage of correct responses of each school has been computed and schoolwise average score in each test item and the total average score has also been determined. The mean scores of 136 male, 65 female and of the total 201 students were found to be 13.9, 14.4 and 14.06 respectively. Overall gender differences have been determined in terms of schools, knowledge, understanding and application. Clinical (itemwise) differences based upon knowledge, understanding and application have also been determined as percentages. Correlation of various abilities like knowledge and understanding; understanding and application; and knowledge and application has been determined with the help of 'r' factor (Garrett and Woodworth, 1981) in both the groups, i.e. males and females. Analysis under various heads is described below.

Gender Differences

The mean score differences in the performance of males and females have been determined for different schools. Differences in terms of knowledge, understanding and application and the overall differences in the performance of boys and girls have been determined with the help of 't' ratio (Garrett and Woodworth, 1981) as described below :

Schoolwise

The mean score (M) of different schools ranged from 10.1 to 16.35 and are given in Table 1. School of the category 'B' run by M.P. State Govt. is found to have the lowest mean score of the order of 10.1. This is a co-educational school and the sample consisted of only male students. Average age of the students is found to be 16.2 years. Though the average percentage marks secured in Class X is found to be 75.1 which is the highest amongst the male students of different schools, yet the students could not do better in this test. Almost the same trend is observed in the case of students

Table 1
Biodata of Students and Their Mean Scores in the Present Test

Category of school	School 'code'	No. of Students			Average Age		Average per cent Marks in Class X		Mean Score in test		School Mean in test (M)
		Male	Female	Total	Male	Female	Male	Female	Male	Female	
Private Management	'A'	10	15	25	16.75	16.62	73.3	74.6	10.16	10.80	10.54
M.P. State Government	'B'	34	0	34	16.2	N.A.	75.1	N.A.	10.10	N.A.	10.10
Public School	'C'	68	17	85	16.89	16.80	68.4	76.5	15.80	15.80	15.80
Missionaries Convent	'D'	0	25	25	N.A.	15.85	N.A.	71.1	N.A.	14.52	14.52
NCERT School	'E'	24	8	32	16.80	16.84	66.2	68.7	15.80	18.00	16.35

NA - Not Applicable

of school of category 'A' which is run by a private management of ladies social worker of Bhopal city. The school mean score is found to be 10.54. In this school, the girls mean score (10.9) is found to be slightly higher than that of the boys (10.16). Amongst students of public school 'C' (M=15.80), convent school 'D' is the remotest area of M.P. (M=14.52), and NCERT run D.M. School 'E' (M=16.35), the performance of students of school 'E' is found to be the best. The females of school E' having a slight edge over the males as per results of Class X public examination, are found to have the highest mean score of 18.0 amongst both boys and girls of all five schools. The above data also indicates that the marks obtained in public examination do not judge the actual achievement level of students due to greater chances of subjectivity which is prevalent in the public examination system in India (NCERT, 2000; Ebel and Robert, 1999; Gupta, 2000). Questions that require students to synthesise information and apply concepts are not very common in such examinations (Raina, 1999; UNESCO, 1998), in both developed and the developing countries. This is the reason that admission in most of the professional courses like Engineering and Medical is done by separate tests consisting of mostly objective type test items thus indicating the need for changing or improving upon the present pattern of examination and evaluation as pointed out in the National Policy on Education (MHRD, 1986)

Knowledge Level

The test consisted of 13 items at knowledge level. Analysis in respect of these items is presented in Table 2.

The average mean score of 136 boys is found to be 7.6 in comparison to 7.7 of 65 girls. The S.D. in case of former is of the order of 2.38 and in case of later it is of the order of 1.83. The 't' ratio is found to be 0.33 which is not significant either at 0.01 level or at 0.05 level. Thus both boys and girls have fared almost equally well in test items which test the factual information or recollection of facts. In case of boys, 58.4 per cent responses and in case of girls 60.8 per cent responses were found to be correct.

Table 2 Comparison of Boys and Girls at Knowledge Level

Sex	*N*	*M*	*SD*	*'t'*	*Inference*	*Per cent correct responses*
M	136	7.6	2.38	0.33	NS*	58.4
F	65	7.7	1.83			60.8

*NS : Not Significant

Table 3 Comparison of Boy and Girls at Understanding Level

Sex	*N*	*M*	*SD*	*'t'*	*Inference*	*Per cent correct responses*
M	136	3.8	1.77	2.59	Sig*	40.0
F	65	4.5	1.82			45.5

*Sig : Significant difference

Understanding Level

Out of the 30 test items, 10 items were of understanding type. A comparison of boys and girls in terms of mean, S.D., 't' value and per cent of correct responses is given in Table 3.

In these test items, the mean and S.D. values of boys were found to be 3.8 and 1.77 for girls as 4.5 and 1.82. The 't' ratio is found to be 2.59. It is just significant at 0.01 level. This shows that there is a significant difference in the performance of boys and girls in test items of understanding type. In terms of percentage of correct responses, 40.0 per cent correct responses have been observed in case of boys as compared to 45.5 per cent in case of girl students.

Application Level

There were 7 test items to test the application domain of the students. The performance of students in respect of these items is given in Table 4.

The data in Table 4 indicates that M and S.D. values for boys in 7 test items and 3.2 and 1.71 as compared to 2.2 and 1.23 respectively which indicate that the performance of boys is better than the girls in test items of application type. The 't' value of the order of 4.76 also supports the view that there is a significant difference in the performance of male and female students in new situations, i.e. application type test items. The general feeling that the female students do not do better when they come across new situations is supported by the percentage data of correct responses also. As compared to 27.9 per cent correct responses in case of female students, 32.6 per cent responses of the male students were found to be correct.

Table 4 Comparison of Boy and Girls at Application Level

Sex	*N*	*M*	*SD*	*'t'*	*Inference*	*Per cent correct responses*
M	136	3.2	1.7	4.76	Sig*	32.6
F	65	2.2	1.23			27.9

*Sig : Significant difference

Table 5 Overall Comparison of Boys and Girls

Sex	*N*	*M*	*SD*	*'t'*	*Inference*
M	136	13.9	4.52	0.83	NS*
F	65	14.4	3.72		

*NS : Not Significant

Overall Performance

Overall performance of 136 boys and 65 girls is given in Table 5.

The mean score of the male students in all the thirty test items has been of the order of 13.9 as compared to 14.4 in case of female students and the S.D. values are 4.52 and 3.72 for males and females respectively. As given in Table 5, the 't' value is found of the order of 0.83 which is not significant. Thus it can be said that in spite of difference in performance in understanding and application type test items, on the whole there has not been found any significant difference in the performance of two sexes. The tilt is slightly in favour of females but not significant.

Clinical (Itemwise) Differences

Clinical analysis of individual test items has also been done to see the difference in performance of boys and girls. For this purpose, analysis has been done separately for knowledge type, understanding type and application type test items. The differences have been measured in terms of percentage of correct responses by boys and girls. Itemwise analysis has been done under the following three heads :

Knowledge Based Test Items

Items no. 1,2,8,11,13-17, 20-22 and 29 were of knowledge testing test items. Their analysis is given in Table 6.

From Table 6, it is clear that the performance of students in recall type test items like composition of substances, definitions, characteristics etc. is good but their performance in items like dealing with bond angle, hydration of ethyne is poor. The performance of girls in items distinguishing between saturated and unsaturated hydrocarbons and cause of chain isomerism is also poor. The reason may be that the students still pay more attention to preparation and properties of compounds (recall) and are unable to discriminate between shapes of different compounds (Gupta, 2000). The same observations are made by Wibler and Henry (1990) and Camacho and Good (1989) in their study on 'Student Ideas Regarding Chemical Equilibrium'.

Understanding Based Test Items

Items no. 4, 6, 7, 9, 10, 18, 19, 23, 26 and 28 were of understainding type and were included in the test to see whether the students really make an attempt to comprehend or understand the concept or they just remember the information by cramming. It is clear from Table 7 that the moment an iota of newness is introduced, the test item proves to be a difficult one for the students.

Table 6 Comparison of Students in Knowledge Based Test Items

Item No.	*Item Content*	*Correct Responses (Percentage)* Boys	Girls
2	Composition of Marsh gas	93.4	69.9
14	Characteristics of homologous series	85.3	90.8
13	Definition of markownikoff's rule	83.1	81.5
16	Characteristics of homologous series	61.0	69.2
20	Distinction test between saturated and unsaturated hydrocarbons	61.0	41.5
1	Type of reaction generally shown by Alkenes	56.0	78.5
8	Cause of chain isomerism	52.2	41.5
17	Main source of organic compounds	50.7	55.4
11	Composition of Baeyer's reagent	48.5	70.8
21	Preparation of Alkanes from Alkyl Halides	48.5	60.0
29	Difference between monomer and polymer	45.6	21.5
15	Bond angle in ethene	39.7	36.9
22	Hydration of ethyne	33.1	46.1

Amongst boys the highest per cent of 49.3 per cent could be achieved for item no. 10 whereas amongst girls the highest score of 60.0 per cent is found for item no. 9, 19 and 23. Identification of acidic hydrogen atom amongst hydrocarbon and the cause of difference in their boiling points proved to be equally difficult for both the sexes. However, more number of females could attempt understanding type items correctly than boys.

Table 7 Comparison of Students in Understanding Based Items

Item No.	*Item Content*	*Correct Responses (Percentage)* Boys	Girls
10	Sigma and Pi Bond	49.3	27.7
19	Formation of free Radicals	48.5	60.0
23	Ozonolysis of alkenes and alkynes	44.9	60.0
7	Anti Markownikoff's Rule-Addition reaction of alkenes	44.1	35.4
18	Planarity about benezene structure	41.0	51.0
9	Bond energy of C-H bond in hydrocarbons	40.4	60.0
4	Cause of difference in boiling point of chain isomers of alkanes	40.4	52.3
28	Cause of difference in boiling points of different alkanes	33.0	33.0
6	Identification of acidic hydrogen atom in hydrocarbons	29.4	30.8
26	Identification of acidic hydrogen atom in hydrocarbons	27.5	41.5

Table 8 Comparison of Students in Application Type Items

Item No.	*Item Content*	*Correct Responses (Percentage*	
		Boys	*Girls*
12	Calculation of Empirical Formula	58.0	44.6
24	Calculation on mole concept	40.4	33.8
3	Determination of oxidation number	44.9	39.7
30	Stability of Carbonium ions	25.0	32.3
27	Application of ozonolysis	23.5	16.9
25	Calculation to determine % of C.H. and O.	22.8	18.5
5	Addition reaction of water and propyne	14.8	10.8

Application Type Test Items

Items no. 3, 5, 12, 24, 25, 27 and 30 constituted the test for testing the application level of the students. Percentage of correct responses in these items is given in Table 8.

In the above test items, the percentage of correct responses ranged from 14.8 to 58.0 for boys and from 10.8 to 44.6 for girls. Item no. 5 proved to be the most difficult test item. Though this item is just an extension of knowledge type item no. 22 which is generally given in the books and the students remember it but the moment it is converted into an application type item, the percentage of correct responses decreased from 33.1 to 14.8 per cent amongst boys and from 46.1 per cent to 10.8 per cent amongst girls. The same trend is observed in items no. 23 (understanding type) and no. 27 (application type) when the percentage of correct responses decreased from 44.9% to 23.5% in case of boys and from 60.0% to 16.9% in case of girls.

Table 9 Structure of Abilities Among Boys (Below diagonal) and Among Girls (Above diagonal)

	K	U	A	N
K	—	0.247 Females	0.157	65(F)
U	0.633 Males	—	0.299	—
A	0.287	0.300	—	136 (M)

for df = 134, p = 0.05, r = 0.169; p = 0.01, r = 0.222
df = 63 p = 0.05, r = 0.250; p = 0.01, r = 0.325

Structure of Abilities

To study the correlation among cognitude faculties, i.e. knowledge, understanding and application abilities amongst the students, the correlation factor 'r' has been determined for both the groups i.e. for males and females. 'r' factors have been determined between knowledge and understanding; understanding and application and beween knowledge and application type items for both the groups separately.

The values of 'r' indicates that there

is a correlation between different abilities amongst male students both at 0.05 and 0.01 level, i.e. the students who are good in knowledge are also good in understanding. Similarly students whose knowledge level is good, their application part is also found to be good. Similarly there is a correlation between understanding and application abilities amongst boys.

In case of girl students there is not found any correlation between knowledge and understanding and knowledge and application both at 0.05 and 0.01 level, i.e. those girls who are good in knowledge ability are not good in understanding and application abilities. However, there is found to be a correlation between understanding and application abilities át 0.05 level i.e. girls who are good in understanding are also good in application ability.

Conclusion

It is clear from a glance over schoolwise mean scores of students given in Table 1, that the mean score of students of Govt. schools is lowest as compared to students of other schools. Hence hypothesis no. (i) is retained. The study has revealed that there is no significant difference in the performance of male and female students as is clear from Table 5. Hence hypothesis no. (ii) is rejected. The most interesting outcome of the study is that the students doing well in knowledge type test items fare poorly if some application type component is added in the test item as reported in Tables 2, 3, 4, 6, 7, 8 and 9. Hence hypothesis no. (iii) is retained. Even then the situation is not very much alarming because at least 27.9 per cent of girls and 32.6 per cent of boys have been successful in attempting the application type test items correctly and 45.5 per cent of girls and 40.0% of boys could respond correctly in the understanding type test items. It is an indication that if the students are exposed to new situations some of them can definitely tackle the new situations with success.

Analysis of abilities (Table 9) shows that the boys who are good at knowledge, are found to perform well in test items based upon understanding and application. There is found to be a good correlation between all the three abilities. However, in case of girl students it is observed that there is no correlation between knowledge and understanding and knowledge and application which means that it is not necessary that the girl students who can fare well in knowledge based test items will also fare equally well in understanding and application type test items. Hence hypothesis no. (iv) is retained. From this study it is also concluded that it is not necessary that a student getting good marks in a public examination will also fare equally well in such objective type tests where subjectivity is reduced appreciably.

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ANNEXURE 1

Achievement Test on Hydrocarbons

Hydrocarbons are the simple class of carbon compounds. You have read this unit in the class. Given below are 30 questions. You are required to choose the correct answers of the following questions. Encircle the correct answer in the given paper.

1. Alkanes generally undergo :
   (a) addition reactions
   (b) substitution reactions
   (c) elimination reactions
   (d) both (a) and (b)
2. Marsh gas mainly contains :
   (a) C_2H_2 (b) CH_4
   (c) H_2S (d) CO
3. The oxidation number of carbon in CH_2 is :
   (a) +2 (b) –2
   (c) 0 (d) –4
4. The compound with the highest boiling point is :
   (a) n-hexane
   (b) n-pentane
   (c) 2, 2-dimethylpropane
   (d) 2-methylbutane
5. When propyne is treated with aqueous H_2SO_4 in the presence of $HgSO_4$ at 333K, the major product is :
   (a) propanal
   (b) propylhydrogensulphate
   (c) acetone
   (d) propanol
6. Acidic hydrogen atoms are present in :
   (a) ethyne (b) ethene
   (c) benzene (d) ethane
7. Anti markownikoff's addition of HBr is not observed in :
   (a) propene (b) 1-butene
   (c) 2-butene (d) 2-pentene
8. An alkane forms chain isomers if the minimum number of carbon atoms is :
   (a) 1 (b) 2
   (c) 4 (d) 3
9. In the series ethane, ethylene and acetylene and C–H bond energy is :
   (a) greatest in ethane
   (b) nearly the same in all the three compounds
   (c) greatest in ethylene
   (d) greatest in acetylene
10. Propyne Molecule contains :
    (a) 2 sigma and 3 Pi bonds
    (b) 5 sigma and 2 pi bonds
    (c) 6 sigma and 2 pi bonds
    (d) 5 sigma and 3 pi bonds
11. Bayer's reagent is :
    (a) Cold, dilute alkaline potassium permaganate solution
    (b) Acidified potassium permanganate solution
    (c) Neutral potassium permanganate solution
    (d) Aqueous bromine solution
12. An organic compound contains 39.9% carbon, 53.34% oxygen and 6.67% hydrogen. Its empirical formula is :
    (a) CH_2O (b) CHO
    (c) C_2H_2O (d) CH_4O_2
13. The negative part of the addendum adds on to the carbon atom joined to the lesser number of hydrogen atoms. This statement is called :
    (a) Thiele's theory
    (b) Peroxide effect
    (c) Markownikoff's rule
    (d) Bayer's strain theory
14. Compounds having a common difference of $-CH_2$ in their molecular formulae are known as :
    (a) isomers (b) allotropes
    (c) homologues (d) polymers
15. Which of the following is closer to the bond angle present in ethylene molecule ?
    (a) 90° (b) 109.5°
    (c) 180° (d) 120°

16. Which of the following statements is incorrect about the members of the homologous series of alkanes ?
   (a) They are all straight chain compounds.
   (b) They have the general formula C_nH_{2n+2}
   (c) They have similar chemical properties.
   (d) They show a regular gradation of physical properties

17. The main source of most organic compounds is :
   (a) Coal gas
   (b) Coal gas and petroleum
   (c) methane
   (d) petroleum

18. Planer structure is shown by :
   (a) ethane (b) benzene
   (c) ethanol (d) acetic acid

19. The homolytic fission of a hydrocarbon results in the formation of :
   (a) free radicals
   (b) carbonium ion
   (c) carbanion
   (d) carbene

20. Which of the following does not decolourise bromine solution in carbon disulphide ?
   (a) acetylene (b) propene
   (c) ethane (d) propyne

21. Ethane would be obtained from ethyl iodide by :
   (a) reducing with Zn–Cu couple and alcohol
   (b) treating with metallic sodium in ether medium
   (c) heating with alcoholic potash
   (d) treating with alcoholic silver cyanine

22. Acetyle on passing through dilute H_2SO_4 containing Hg^{2+}, forms
   (a) acetone
   (b) propionaldehyde
   (c) acetaldehyde
   (d) formaldehyde

23. Which of the following reactions gives glyoxal ?
   (a) $CH_2 = CH_2 + O_3 \xrightarrow{\text{ozonolysis}/H_3O^+}$
   (b) $HC_2 \equiv CH + O_3 \xrightarrow{\text{ozonolysis}/H_3O^+}$
   (c) $CH_2 = CH_2 + HOCl \longrightarrow$
   (d) $CH_2 = CH_2 + HCN \longrightarrow$

24. The volume of CO_2 evolved on complète combustion of one mole of ethylene with excess of oxygen at STP in litres is :
   (a) 22.4 (b) 44.8
   (c) 2.24 (d) 67.2

25. An organic compound contains C, H and O. 0.24 g of the compound gave on combustion 0.22 g of CO_2. It is contains 1.66% of H, then the percentage of C and O will respectively be :
   (a) 12.5 and 36.6 (b) 25 and 73.3
   (c) 25 and 36.6 (d) 25 and 80

26. Number of acidic hydrogen atoms present in 1–butyne is (are)
   (a) 2 (b) 3
   (c) 1 (d) 4

27. The alkene which on ozonolysis and hydrolysis yields acetone is :
   (a) $H_2C = CH_2$
   (b) $H_3C{-}CH = CH_2$
   (c) $(H_3C)_2\ C = C(CH_3)_2$
   (d) $H_3C - CH = CHCH_3$

28. Highest boiling point is expected for
   (a) iso-octane
   (b) n-octane
   (c) n–butane2,2,3,3 - tetramethylbutane
   (d) n-butane

29. $CH_2 = CH_2$ is a/an
   (a) monomer (b) polymer
   (c) isomer (d) epimer

30. The stability of carbonium ions is in the order:
   (a) $H_3\overset{+}{C} > CH_3{-}\overset{+}{C}H_2 > (CH_3)_2\overset{+}{C}H > (CH_3)_3\overset{+}{C}$
   (b) $(H_3C)_3\overset{+}{C} > (CH_3)_2\,\overset{+}{C}H > CH_3 - \overset{+}{C}H_2 > \overset{+}{C}H_3$
   (c) $(H_3C_2)\overset{+}{C}H > (CH_3)_3\overset{+}{C} > \overset{+}{C}H_3 > CH_3 - \overset{+}{C}H_2$
   (d) $H_3C\,\overset{+}{C}\,H_2 > \overset{+}{C}H_3 > (CH_3)_2\,\overset{+}{C}H > (CH_3)_3\,\overset{+}{C}$

Helping the Underachievers in Science

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We have now entered the twenty-first century with a strong background of scientific and technological advancement. The twentieth century saw several revolutions taking place in human civilisation. The agricultural revolution, which made us self sufficient in food was followed by industrial revolution. Now we are heading towards the information technology revolution. But at the root of all this has been the knowledge of science, which is so essential for everybody in the modern age. Education Commission (1964-66) has rightly remarked "A basic distinction between traditional and modern societies in the development and use by the latter of science based technology, which helps modernisation of agriculture and the development of the industries. In a traditional society production is based largely on empirical processes, experiences and trial and error, rather than on science, in a modern society, it is basically rooted in science."

If we are to keep pace with the developed countries in all fields, we have to strengthen our base in scientific and technological knowledge and skills. But we have to start it from school stage. It is at the school stage that the foundation for advance learning in all fields is laid. We have to improve the quality of science teaching at school stage by upgrading curricula, developing proper infrastructure and equipping teachers with the latest skills in teaching. The teaching of science at school stage should promote an ever deepening understanding of basic principles, develop problems solving and analytical skills and then ability to apply them to the problems of the material environment, and promote the spirit of enquiry and experimentation.

The learning of science is compulsory for all children up to Class X in our present school curriculum. We have to ensure that every child acquires minimum level of knowledge and skills in science. Kothari Commission rightly stated "The need from the earliest stage of science education for a proper understanding of the basic principles and the process of scientific abstraction and creative thinking must be emphasized."

A normal learning situation consists of a teacher, a room with or without necessary furniture, chalk, duster and large group of students with varying levels of ability, background and motivation. In such a classroom the teacher variables and learning environment variables are constant for a given groups of students. But the learner variables are different for every individual learner. It is these learner variables that are responsible for variation in learning or academic achievements.

In a given teacher and a classroom the learning of a skill or competency depends on three major factors related to the learners —

- ☐ His innate ability to learn
- ☐ The opportunity, which he received
- ☐ His level of motivation.

It is believed that ability is a single most important factor that determines the level of learning or achievement. But the role of opportunity (socio cultural and familial environment) cannot be underestimated. It has been established by numerous research studies that sociocultural background variables are no less important than intellectual abilities.

Who is an Underachiever ?

Any child who falls below the average of all children is thought of as an underachiever. Suppose a student performs better relative to the average of his age or grade group, on a test of aptitude or mental ability than on an achievement test in some subject matter field. Such a student is termed as an underachiever.

Kowitz and Armstrong explained the underachiever as the pupil who is not working hard enough to achieve to the limits allowed by his abilities.

Methods of Identifying Underachievers

Broadly speaking techniques and procedures of identifying underachievers can be classified into three broad categories —

- ☐ Variability in achievement at Constant level of intelligence.
- ☐ Discrepancy between achievement and intelligence.
- ☐ Discrepancy between observed and predicted achievement.

It is an important fact to note that earlier the identification of the underachiever better for them to get the treatment accordingly.

Underachievement in Science

Srivastava (1967), Dhaliwal (1971), Menon (1972-73), Abraham (1974), Chaudhari Jain (1975), Agarwal (1975), Beedawat (1976), Singh (1983), Gupta (1983), Haq (1987), Puri (1987) studied different factors influencing academic under overachievement in general.

But there are very few researches, which were done on underachievement in science. Mathews (1976) studied some personality factors related to underachievement in science. The study revealed that —

(a) The mean scores of normal achievers exceeded significantly the mean scores of underachievers for variable like sense of personal worth, sense of personal freedom, withdrawing tendencies, social standards etc, and the mean scores of normal achievers were significantly less than the mean scores of underachievers in test anxiety and maladjustment

(b) The mean scores of overachievers were significantly greater than those of the normal achievers in case of sense of personal freedom, social standards and family relations.

(c) The mean scores of overachievers significantly exceeded the mean scores of underachievers in case of self reliance, sense of personal freedom, freedom from withdrawing tendencies, freedom from nervous symptoms, social standards, social skills, freedom from antisocial tendencies, family relations and community relations.

(d) A higher number of overachievers were of the high intelligence low age group amongst boys and amongst the parents with higher education than their respective counterparts.

(e) Greater number of overachievers were found amongst high income urban subjects, and

(f) Four factors — total adjustment, anxiety orientation, group adjustment and self esteem — accounted for total variance of the overachieving group and five factors — personal adjustment, social adjustment, social facilitation, leadership and self acceptance—accounted for the total variance of the normal achieving group.

Siddiqui (1983) made a study on environmental factors related to underachievement in science. The main purpose of the study was to find out —

(a) Relationship between socio-economic and educational factors and achievement in general science.

(b) To study the impact of ineffective teaching on underachievers in science. On the basis of data consolidated, it was concluded that home and school environment play a significant role in poor achievement. The overall findings of the present study supports the hypothesis that low achievers in science come from home having low income, low social status and low educational attainment of parents. It further supports the second hypothesis as well as that ineffective teaching in science results into underachievement in pupils.

Chauhan (1992) studied relative contribution of some sociocultural and familial variables to over and underachievement in science. On the basis of the data it was concluded that —

(a) the correlation coefficients between intelligence and most of the sociocultural and familial variables were statistically significant.

(b) Family income, parent education, family occupation and sociocultural background had significant correlation with academic achievement in science for the sample of boys and girls.

(c) Underachievement among boys were mainly determined by family income and parent education. The children of parents with low education are likely to be underachievers.

(d) In case of girls none of the predictor variables happens to be potential predictor of underachievement of science.

(e) Underachievement in the combined sample was determined by family income and parent education.

(f) The overall inspection of results

obtained from multiple regression analysis show that sociocultural background and family occupation are important boosters of achievement in science. Similarly, low parent education is the root cause of underachievement. The family income plays a catalytic role in the sense that it boosts overachievement in the children of high educated rich and also boosts underachievement in the children of less educated rich.

There is a very interesting study conducted on the school students of science concerning the method of teaching like to mention here.

Salvi (1999) conducted a study on the school student of science in Delhi and arrived at the conclusion that it is the science teaching, which is at fault in schools primarily because most of the teachers have no interest in science or popular science books or science fiction. They are simply doing their duties and are only interested to complete the syllabus within the scheduled time. In other words no effort is made to create an interest in science among children.

Suggestions

There are numerous quality learning opportunities that may be provided for learners in ongoing science lessons and units of study. These opportunities need to provide for individual differences in the classroom such as pupils with diverse level of achievement. Here are some suggestions to help underachievers in science.

(a) A compensatory education programme should be conducted in every school for underachievers.
(b) Special classes in each subject should be conducted in every school for unerachievers.
(c) Science teacher needs to provide activities and experience for underachievers which are purposeful.
(d) Science teacher must provide activities and experiences that are interesting to the learner so they may learn, achieve upto the mark and grow.
(e) Science teacher needs to provide activities and experiences for pupils that are reflective in nature so that students individually ponder over what has been taught.
(f) Science teachers should continually find new and better methods of instruction to guide increased level of pupils achievement.
(g) The books recommended for supplementary reading in school should have the following topics —
    (i) What is science ?
    (ii) History of science.
    (iii) Biographies of scientists and inventors.
    (iv) Impact of science on society.
    (v) Anecdotes, humour and stories in science.
    (vi) Questions and answers in science.
    (vii) Exposure to science fiction.
    (viii) Exposure to science puzzles and treasures.

We must note that the sole responsibility of helping these children does not lie only on the science teachers and educational institutions, but parents and family members should also provide activities and experiences to underachievers which could motivate and help them in understanding the subject matter. The parents should provide them good science books, bring them to an excursion, science clubs, museums, science exhibitions etc. Show simple demonstrations at home. The most important suggestions to the educated parents that they should never discourage the questioning of the children regarding scientific facts and phenomenon which are happening around them.

At last, we can say, by the mutual understanding and coordination of family and educational institutions we can help these children upto a great extent.

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Developing and Implementing Physics Investigatory Projects at Senior School Level

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MANY EDUCATORS (Elton, 1979; Vaidya, 1989; Singh, 1991) lament poor quality of practical work in physics at the senior school level though laboratory work occupies a considerable part of students' time. According to Gangoli (1980), Physics is an ongoing enterprise. In physics, new and exciting questions crop up for which solution need to be found through exploration and investigation.

Of late, the Central Board of Secondary Examination has made investigatory projects in physics compulsory at the senior school level. According to CBSE (1991), physics investigatory project is a problem-based act carried to completion in its natural setting to achieve the intended objective; independent study or mini-research or open-ended work.

Unfortunately, to most teachers, a physics project means building a gadget or displaying an instrument of physics. The reason for this state of affairs is the lack of preparation on the part of physics teachers and non-availability of enough resource material on physics investigatory projects at the school level.

Some of the important studies done in the area of physics investigations at school level are as follows :

Driver (1972) found that physics investigations increase the spontaneous reasoning and ability to suggest alternative framework.

Hanks (1980) implemented a course based on physical and scientific analysis and found that it changed the scientific attitude of students significantly.

Okebukola (1985) examined the effectiveness of cooperative, competitive and individual patterns in acquisitions of skills of scientific process during laboratory activities. The results showed that competitive interaction was superior to cooperative and individualistic interaction patterns in promoting the development of laboratory skills.

Carvarna and Leonard (1985) found that in order to gain full benefit from physics investigations at the school level, the students need more enthusiastic and patient supervision and guidance.

Similarly, studies by Kale, 1960; Singh, 1972 and Saraswat, 1977 have shown the worth of scientific investigations at the school level. But, most researchers have felt the lack of resource material for physics investigation and orientation of teachers to implement such work effectively in the school situation.

Objectives of the Present Study

The present project entails the following objectives.

1. To study of the present status of physics investigations at the senior school level.
2. To develop and validate physics investigatory projects at the senior school level.
3. To study the effect of physics investigations on (a) scientific attitude and (b) understanding of science.

Hypotheses

The following hypotheses stated in the null form were tested.

1. There will be no significant differences in the scientific attitude of the sample before and after the treatment of investigatory projects in physics.
2. There will be no significant differences in the understanding of science by the students of the sample before and after the treatment of investigatory projects in physics.
3. There will be no intra-group differences of the sample on scientific attitude and understanding of science before and after the treatment.

Methodology

To start with, a status study of physics investigations by interviewing some typical physics teachers and practical examiners was done and insight was gained about the difficulties faced by teachers in implementing physics projects. Thereafter, a large number of physics investigations were developed by the investigators in the form of project briefs, title and keywords. the content validity was done by experts (N=6) and the project ideas were reorganised as per their suggestions. The inclusion of pre-investigation activities and sequencing of physics investigations was done on the basis of the suggestions made by experts.

The physics investigations were done by students of Kendriya Vidyalaya (N=25, Age=17) who formed the quota sample for the study. The projects were implemented for eight block periods spread over a month. The pre-test and post-test for scientific attitude and understanding of science were conducted to obtain the data. Also Cattell's culture fair group intelligence test was conducetd on the sample for intra-group studies. The before-and-after experimental design of study was used for the project. The t-test, chi-square test and U-test were used for analysis of data.

Results

The present project resulted in the development of the following resource materials :

1. Twenty pre-investigation activities
2. Fifty project briefs
3. Thirty project titles with hints
4. Twenty-six project titles
5. Fifty-six more project ideas
6. Two hundred keywords for project ideas.

Besides the resource material, the data collected at the teacher level and student level showed the result given in Table 1.

The gains in scientific attitude and understanding of science for the sample are given in Table 2.

Table 1

Dactum	*d.f.*	*Ch-square*
Need for Investigatory projects	9	90**
Need for resource material	2	39.63**
Need for holding inservice orientation	2	21.38**
Preference for resource material (formal)	2	1.13 (N.S.)
Experts opinion on draft material	2	15*

** Significant at 0.01 level
* Significant at 0.05 level
N.S. = Not significant

Table 2 Gains in Scientific Attitude and Understanding of Science

Dactum	*N*	*R*	*U*	*Z*
Scientific attitude	25	272	686	6.61**
Understanding of science	25	324.5	626.5	5.56**

** Significant at 0.01 level

Intra-group comparison of students for gains in scientific attitude and understanding of science are shown in Table 3.

Conclusion and Discussion

The following conclusions were drawn from the study.

1. Students gained significantly at 0.01 level in their scientific attitude due to physics investigations, thereby rejecting hypotheses H-1.
2. Students gained significantly at 0.01 level in their understanding of science thereby rejecting hypotheses H-2.

In the light of the results of the studies, the following recommendations are made —

1. Production of resource material on physics investigatory projects by the NCERT, SCERT, CBSE etc.

Table 3 Intra-group Comparison

Sub group	*Scientific attitude gains*			*Understanding of Science gains*			
	R	*U*	*Z*	*N*	*R*	*U*	*Z*
High group	25.0	32.0	2.44**	6	58.9	29.8	0.4 (N.S.)
Middle group	22.5	39.5	2.64*	6	48.5	1.5	2.54*
Low group	39.0	18.0	0.1 (N.S.)	6	29.5	18.5	0.77 (N.S.)

** Significant at 0.01 level
* Significant at 0.05 level
N.S. = Not significant

2. Encouragement to research and dissemination of research findings.
3. Publication of special journals on physics investigatory.
4. Conduction of awareness courses for institutional heads.
5. Forging industry-school link-ups.
6. Starting scientist mentor schemes.
7. Holding orientation courses for physics teachers.
8. Holding children's science congress.

There is no doubt that investigatory projects in physics have far-reaching implications in making physics instruction process-based. It is through such projects only we can bring learning to operational level and produce better understanding of physics concepts, self-initiative and self-learning among students.

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Adolescent's Intuitive Conceptions about the Respiratory Organelles of Two-Invertebrate Animals

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Human beings construct their own meaning(s) at the personal as well as at the social level. Therefore, *knowledge* is a creative transformation of experience, and it cannot be transferred intact from 'the head of the teacher to the heads of the students' (Lorsbach and Tobin, 1992). Interaction of the individuals with the environment, i.e., events, objects and persons etc. creates *'a cognitive complex'* (Graham and Berry, 1993—a network of information, images; relationships, expectations and inferences around an idea) and it forms what Grahm and Berry call his/her conceptions about a reality. Therefore, every individual on the basis of the past experiences and level of cognitive negotiability builds a personal model of reality (Johnson-Liard, 1983; Pachaury, 1995). This view of human learning is equally well supported by the genetic epistemologists, cognitive theorists, (Von Glasersfeld 1989); and even by the social constructivists (Bakhtin, 1981; Bearison, 1982; Damon, 1993; Mugney and Doise, 1978; O'Loughlin, 1922; Perret-Clermont, 1980; Vygotsky, 1978).

According to the Genevan school (Piaget, 1950), the creation of knowledge by the learner is acquired in four invariant stages of cognitive development. The infant (0-2 years) generates experiences by applying sensori-motor actions on the objects, etc. For the pre-operational child (2-7 years), the chief source of knowledge creation is carried through the semiotic representations. This mode of information generation lacks logical rigour, and therefore, children had to bank upon intuitive thinking in responding to a reality, i.e., be it natural, biological and/or psycho-social in nature. Pulaski (1980), describes pre-operational child's thinking in the following manner :

> Intuitive thinking lacks the stable, reversible character of true operational thinking. Reasoning is still symbolic, based on subjective intuition rather than objective logic.

Intuitive thinking, therefore, is 'a personal construction that fits the external reality and allows us to survive in the environment' (Tobin, 1990).

Learning beyond the pre-operational stage of cognitive development (Concrete operational thinking, 7 to 11/12 years) depends on logical operativity of conservation, classification and/or relationships in creating meanings from concrete stimuli. Abstract meanings start crystalizing about the age of eleven years, and hence, the learner, who manifests this kind of information processing, is designated as a 'formal operational thinker' or hypothetico-deductive thinker.

Problem-solving is essentially a 'complex multilayred skill' (Bolton et al., 1997). Novices employ 'surface features' of the problem to solve it, while the experts execute strategies that are backed by 'hierarchical large principle-oriented patterns' (Chi et al., 1981, 1988; de Jong and Ferguson-Hessle, 1986; Zajchowski and Martin, 1983). Hafner and Steward (1995) have argued that problem-solving requires '(a) conceptual understanding of a discipline; (b) general and domain — specific problem-solving heuristics; and (c) insights into the nature of that discipline as an intellectual activity'. Research evidence also suggests that Ss had employed intuitive strategies in solving mathematical problems (Fuson, 1992; Hiebert, 1992; Kieran, 1992; Stevenson and Stigler, 1992). Scientists too had been employing intuitive thinking regarding a discrepant observation of their investigated reality. But, they do so, within the rubric of a pursued theory, rather than just simply adopting a wild conjecture (Pachaury, 1996). According to McClelland. (1984), children do a lot of spontaneous theorizing about science-related phenomena. Early, middle and late adolescents and teachers have manifested a lot of alternative conceptions about scientific realities (Pachaury, 1986; 1989, 1994, 1998).

Common earthworm is a ringed invertebrate animal (Phylum-Annelida), and does not have a specialized respiratory organelles like the lungs of the vertebrates. Its natural habit is moist soil, therefore, it employs whole of its body surface for exchange of respiratory gases. A house spider on the other hand, inhabits a dry aerial place. In comparison to an earthworm, a spider occupies a higher place in the evolutionary scale, but it too lacks lungs as respiratory organelles. Rather these arachnids (Phylum-Arthopodda) have *booklungs* as respiratory structures. Structural-functional complimentarity of a species, at times cannot be neatly structured logically by the novices for the simple reason that an animal's speciation has been carried through many years of evolutionary processes. In the absence of such a specialized biological knowledge-base, a novice problem-solver, when exposed to a discrepant biological reality, in all probability, would regress mentally, and therefore advance an intuitive conception for his/her conjecture.

Keeping in view the above cited observations regarding exploration of discrepant biological reality by the novices, the following research questions have been coined for empirical confirmation—

(a) What types of intuitive conceptions do adolescents employ, when faced with a discrepant biological reality about the respiratory organelles of two invertebrate animals ?

(b) Do these adolescents employ a large number of the non-plausible conceptions for the respiratory organelles of a less familiar invertebrate animal ?

Sample

Sixty-nine ninth grade adolescents formed the sample of this study. Their age range was between 14 and 15 years.

Tasks administered

The data were collected by the author in the regular classrooms of the sampled Ss. They were requested to answer the following two questions :

Q1.An earthworm hasn't got the lungs. How does it then respire ?

Q2.A house spider too hasn't got the lungs. How does it then respire ?

Scoring

From the responses generated by the sampled Ss, frequencies were derived and on the basis of the structural similarities of the created respiratory organelles, five categories of the intuitive conceptions were formed as shown in Table I.

Table I Types of intuitive conceptions created by the sampled subjects.

I Plausible conjectures

In this category intuitive conceptions that were considered to be very close to the actual structures of respiration in these two invertebrate animals were put, i.e., *the skin, body and pores on the body.*

II Juxtaposed conjectures

In this category respiratory organelles like *mouth, nose* and *nostrils* were considered, because one of the chief characteristics of the pre-operational subject is that he/she employs *transductive thinking* (Piaget, 1952). The subjects juxtaposed their respiratory structures for an earthworm/spider as well.

III Remote conjectures

In this category, those intuitive conceptions were included that were neither plausible nor that were close to human respiratory organelles. Therefore, this category contained structures like, *Back; Fins; Gills; Legs; Lines on the body; Palm; Scales; Tube; Web; and Wings.*

IV Physical object conjectures

In this category, all those intuitive conceptions that had physical attributes were put, for example, Atmosphere; Air, Chemical (body), Directly; Diffusion; Glue (body); Respires and Water.

V No Response

In this category, the subjects who did not respond to the administered questions and who also repeated the questions were put.

From the interpretation point of view, the juxtaposed, remote, physical objects etc. and no response categories of the conjectures were clustered into a super-originate category of *non-plausible conjectures* (II to V).

Results

These adolescents were pursuing CBSE curriculum and their science teachers confirmed that no formal instruction was held regarding the respiratory organelles of these two invertebrate animals (e.g. earthworm/spider). Therefore, whatever conjectures these Ss had created regarding the respiratory organelles of these two invertebrate animals have been taken as indices of their intuitive conceptions because, their manifestation is revealed through generation of inferences to solve new problems (Anderson and Thompson, 1989; Gentner and Gentner; 1993, Mayer, 1989).

Plausible V/s non-plausible conjectures

Of the 33 boys and 36 girls, who responded to the two respiratory structures of an earthworm and a spider, 51.51% of the boys and 52.77% of the girls made plausible conjectures (skin, body and pores on the skin) about the earthworm's respiratory structure. These percentages dropped down to 15.15% and 19.44% respectively for the spider's case (Table II)

Table II Number of the subjects who created different types of the intuitive conception

	Conjecture	Boys		Girls	
		Earthworm	Spider	Earthworm	Spider
I	*Plausible*				
	Skin	12	2	16	3
	Body	2	1	3	2
	Pores	3	2	—	2
II	*Juxtaposed*				
	Mouth	2	6	3	5
	Nose	3	1	2	3
	Nostril	—	—	1	1
III	*Remote*				
	Back	—	—	1	—
	Fins	—	2	—	—
	Gills	5	1	—	—
	Legs	—	8	—	6
	Lines	—	—	1	—
	Palm	1	—	—	—
	Scales	—	—	1	—
	Tube	1	1	1	1
	Web	—	—	—	4
	Wings	—	1	—	—
IV	*Physical Object*				
	Atomsphere	—	1	—	—
	Air	—	—	1	1
	Directly	—	—	1	—
	Diffusion	1	—	1	1
	Chemical	—	1	—	—
	Glue	—	1	—	—
	Respires	—	—	1	—
	Water	—	—	1	—
V	Repeated	1	I	—	—
	No response	2	4	2	7
	N	33	33	36	36

For the juxtaposed conjectures (Cat II-mouth, nose nostrils), the percentages for the earthworm's respiratory organelles were 15.15 and 16.66 for the boys and girls, respectively. In the case of the spider, these percentages increased to 21.21 and 24.99, respectively for the either gender (Table II). There was an increase in the percentage of the remote conjectures (Cat III) for the boys (from juxtaposed to remote category) for the earthworm's respiratory organelle, i.e., from 15% to 21% while for the girls this trend was reversed, i.e., from 16% to 11%. However, for the either gender, the percentages increased for the spider's respiratory organelles in terms of the remote category of the conjectures (boys, from 21% to 39% and girls, from 25% to 31%).

For the fourth category of the conjectures, (physical objects), the percentages for the either gender were from 3% to 14% for the two categories of the animals' respiratory organelles. However, more number of the adolescent girls, employed this category of the conjectures for the earthworm's respiratory organelle.

Six to 19% of these sampled adolescents did not respond to the questions posed to them (Cat V).

In order to ascertain, whether there exists a significant difference between the percentages of the plausible conjectures generated by the either gender for the two invertebrate animals' respiratory structures, the Omega statistic were calculated. The obtained values of the Omega (ws'), support the view that the either gender generated significantly less number of the plausible conjectures for the spider's respiratory organelle in comparison to that of an earthworm's respiratory organelle (boys, w=0.34 critical; w=0.41, $p<0.05$; girls, w=0.32 critical; w=0.36, $p<0.05$).

For the either gender, there does not exist any significant difference between the percentage of the respiratory organelles of the two invertebrate animals for the remote, and physical object conjectures, i.e., categories II to IV.

Calculations of the Omegas' also confirm that there does not exist any significant difference between the generated plausible conjectures (Cat I) and non-plausible conjectures (Cats II to IV) of an earthworm's respiratory structures by the either gender (boys, w=0.34 critical; w=0.14, $p>0.05$; and girls, w=0.32 critical; w=0.13, $p>0.05$).

For the spider's respiratory organelle, both the boys and the girls, generated significantly more number of non-plausible conjectures in comparison to that of the plausible ones (boys, w=0.34 critical; w=0.63, $p<0.05$ and girls w=0.32 critical; w=0.46, $p<0.05$).

Discussion

When exposed to a discrepant biological event, the sampled ninth grade adolescents employed a variety of intuitive conceptions about the respiratory organelles of the two invertebrate animals (Table I). This observation has been supported by the other researches across the cultures that children/adolescents have their own intuitive conceptions of scientific realities (Boo, 1998). Scientists too shape their science, on the basis of 'the personal beliefs' that are 'backed by a persued theoretical paradigm (Pachaury, 1996). Therefore, what the scientists do, i.e., they create mental model of a persued reality and empirically validate it, should also form an integral part of the teaching of science to the students.

Children being immature in having domain-specific knowledge-base, hence, they need academic guidance from their teachers to behave like a scientist at least in the initial phase of development of experimental skills. Since, children/adolescents create their own meanings about a given situation, on the basis of their past experiences as well as the level of logical schematization of their interactions with the scientific realities. The beginning of sciencing (Brandwein, 1958) by them, therefore, cannot ignore what they already know about a reality (Ausubel, 1958). Most of the science learning by these adolescents was completed by listening to the teachers presenting textbook information about science, therefore, *sciencing* by them would need hands-on experiences.

Concept development primarily takes place in the context of 'the embedded framework of prepositions' (Novak et al., 1983). The initial *sciencing* by the students' need building their categorizing and relating mental schemes, therefore, inquiry experiences should hinge on Observation-measurement—inference modes of information processing (i.e., single-variable experiments). Higher-order inquiry activities that entail making of a prediction and generation of a hypothesis and its empirical validation (acceptance, rejection and/or modification) requires construction of a second-order inferencing in the form of new prepositions to be experimentally tested. These sciencing experiences develop and nurture hypothetico-deductive reasoning abilities of the students (Pachaury, 1990, 1990 a, b; 1967). An action plan for sciencing by the students that would minimize their conceptual schizopherenic (Hodson, 1986) behaviour by promoting reconstruction of a scientific reality through the process of conceptual change is presented below :

a. *What to investigate* depends on creation of a prediction and its experimental testing or challenging the existing conceptions about a scientific reality and then generating a testable preposition (a hypothesis).
b. *How to investigate* requires isolation of the investigated variable and controlling of the other variables.
c. *Doing experiment* for observing/making measurements and recording of the investigated variable (generation of the data).
d. *Drawing inference* cause-and-effect relationship is established on the basis of reliability and honestly collected data.
e. Interpreting data demands a second-order of inferencing keeping in view the past observations/evidences (accepting, rejecting and/or creation of a preposition for experimentation).
f. *Critical evaluation* of the experiment is required through open discussion for meeting the requirement of *consensible and consensus criteria* of good sciencing.

g. *Reporting* for making others aware of the results of the experiment.

These steps of *sciencing* have been created on the suggestions of (a) Kuhn's (1970), 'normal and revolutionary science activities', (b) Ziman's (1980), 'consensible-expressed in, mutual intelligible and unambiguous language,' and 'consensual—the ultimate criteria for validating science' criteria, and (c) for the nurture of both the cerebral hemispheres of human brain (Pachaury, 1985, 1991, 1997).

Reference Notes

(a) Why do children, adolescents and adults have intuitive conceptions of scientific reality is supported on the ground that 'individuals make inferences, elaborate on new information by adding details and generate relationships among the new ideas and between the new material and information already in memory (Brown et al. 1986; Pressley et al., 1992; Thomas and Rohwer, 1986; Wittrock, 1990, cited by King, A and B. Rosenshine (1993).

(b) The learning process emphasizes the role of the life experiences in the formation of the ideas (Von Glasersfeld, 1989, 1992).

(c) The alternative knowledge developed by children is relevant to make sense to them in specific situations. It is deeply embedded in the cognition of the individuals (di Sessa, 1983), and

(d) The learners bring various levels of knowledge, skills and understanding to a problem situation (Cynthia and Quinn, 1997).

Boo (1998) has argued that the following labels have been interchangeably employed by the researchers about the student's science conceptions —

(a) Naive beliefs (Caramazza et al., 1981);
(b) Preconceptions (Anderson et al., 1988);
(c) Alternative frameworks (Driver and Easley, 1978; Driver and Erickson 1983);
(d) Children's science (Gilbert et al., 1982);
(e) Naive theories (Resnick, 1983);
(f) Naive conceptions (Champagne et al., 1983);
(g) Intuitive beliefs (McCloskey, 1983);
(h) Intuitive science (Precea, 1984);
(i) Learners science (Wittrock, 1985); and
(j) Misconceptions (Cho et al., 1985; Griffiths and Grant, 1985).

Lastly, it is important for teachers to recognize the differences between real science and children's intuitive view of the world (Hodson, 1986).

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Formula of 'Copper (II) — Ammonia' Cation Quantitative Technique

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HYDRATED copper sulphate solution reacts with liquor ammonia to form a blue coloured complex $[Cu(NH_3)_4]\ SO_4.H_2O$. In the beginning, blue precipitate of copper hydroxide, $Cu(OH)_2$, is formed which dissolves in excess of ammonia. Overall reaction that takes place is

$$CuSO_4 + 4NH_3 + H_2O \rightarrow \underset{\text{Blue Complex}}{[Cu(NH_3)_4]\ SO_4.H_2O}$$

A similar reaction takes place when anhydrous copper sulphate (white solid) is reacted with liquor ammonia to form a complex, which is also blue in colour. Keeping the above reaction as a base, here an attempt has been made to arrive at the formula of 'Copper (II) – Ammonia' cation through quantitative consideration.

Materials Requirement

Copper sulphate pentahydrate, liquor ammonia, silica crucible, electrical balance, small gas jar, jar-cover, spatula, desicator.

Theory

Copper sulphate pentahydrate is blue in colour. At 100°C, it loses three molecules of water; between 100°C to 110°C, it loses another molecule of water. At this temperature, it is almost white in colour. At 600°C, it becomes anhydrous and perfectly white in colour.

$$\begin{tikzcd} \underset{\text{Blue}}{CuSO_45H_2O} \arrow[r, "100^0C"] & \underset{\text{Blue}}{CuSO_4.2H_2O} + 3H_2O \arrow[d, "100 - 110^0C"] \\ H_2O + \underset{\substack{\text{White}\\ \text{(anhydrous)}}}{CuSO_4} & \underset{\text{White}}{CuSO_4.H_2O} + H_2O \arrow[l, "600^0C"'] \end{tikzcd}$$

If a known amount of $CuSO_4.H_2O$ is made to react with liquor ammonia then a blue coloured cationic complex of tetrammine copper (II) is formed. This can be dried and weighed. From the difference in weight of the complex formed and the $CuSO_4.H_2O$ taken initially, the weight of ammonia molecules in the complex can be determined. In the complex formation, ammonia molecules act as a monodentate ligand. These ligands attach themselves to the metal ion depending upon coordination number of the metal ion. From the weight of ammonia ligands coordinated to the copper (II) cation, the formula of the complex cation can be determined quantitatively. Copper (II) cation reacts with ammonia as follows :

$$Cu^{++} + xNH_3 \rightarrow \text{Royal BLUE COLOUR}$$

If the royal blue colour is due to only one kind of molecules then it has the formula $[Cu(NH_3]x]^{++}$. From the experimental data, 'x' can be determined to the nearest whole number which will give the number of ligand molecules attached to copper metal ion. From the number of ligands attached to Cu(II), formula of 'Copper (II) Ammonia' cation can be ascertained.

Procedure

Weigh empty clean silica crucible with the help of an electrical balance. Cover its bottom with about one spatula measure of $CuSO_4.H_2O$ (at 110°C). At this temperature, it is almost white in colour. Cool it in a desicator and weigh again. Difference of these two weights will give the weight of $CuSO_4.H_2O$.

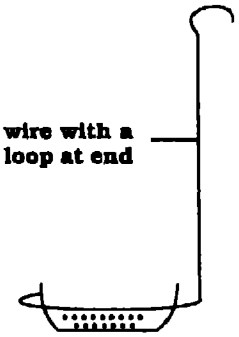

Fig. 1

Fill a small gas jar to a depth of about 100 mm with liquor ammonia solution. Lower the crucible containing $CuSO_4.H_2O$ into this gas jar using a looped wire as shown in Fig. 1 until it rests on the bottom of the gas jar. Ensure that no liquid comes into contact with the solid. Put a glass cover over the gas jar as shown in Fig. 2. Observe the change in colour as the reaction proceeds. Allow the reaction to complete. Remove the crucible and find its weight again. Then expose the solid to the ammonia gas for a few more minutes and repeat this process. Keep in finding the new weight and re-exposing the solid to the gas until the weight becomes constant. Find the increases in weight due to formation of the complex compound. Data collected through an experiments as suggested above are presented here to illustrate the procedure.

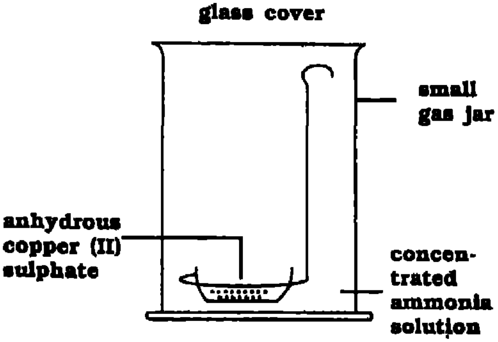

Fig. 2

Observations

(i) Weight of empty silica crucible = 18.56250 g

(ii) Weight of crucible + $CuSO_4.H_2O$ = 19.09370 g

(iii) Weight of crucible + $[Cu(NH_3)x]$ $SO_4.H_2O$ = 19.29710 g

Calculations

Weight of $CuSO_4.H_2O$ =
19.09370 − 18.56250 = 0.53120 g

Weight of $[Cu(NH_3)x]$ $SO_4.H_2O$ =
19.29710 − 18.56250 = 0.73460 g

Molecular mass of $CuSO_4.H_2O$ =
63.55 + 32 + 64 + 18 = 177.55 g

Molecular mass of $Cu(NH_3)x\ SO_4.H_2O$ = $(177.55 + 17\ x)$ g.

For the determination of 'x'

$$\frac{177.55 + 17x}{177.55} = \frac{0.7346}{0.5312} \Rightarrow x = 3.99$$

which can be taken as equal to FOUR. Therefore, number of NH_3 ligands attached to copper metal ion = Four. In other words, coordination number of the copper metal ion in this complex is four. So the formula of copper ammonia cation of copper ammine cation = $[Cu(NH_3)_4)]^{++}$

Hazards of Chemicals Used

Liquor ammonia is a poisonous, pungent smelling liquid. Its bottle should be opened at low temperature. Only a limited amount of liquid ammonia should be added for complex formation.

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Science News

Excellent Performance by the Indian Students at International Olympiads

International Olympiad in Physics, Chemistry, Biology and Mathematics for 2001 were organized by the respective International Olympiad Organisations between June 28 and July 16 at four different venues around the globe. India had the privilege of hosting the International Chemistry Olympiad (ICHO) 2001 at Mumbai. Homi Bhabha Centre for Science Education (HBCSE), Mumbai organized the International Chemistry Olympaid (ICHO) 2001 in collaboration with the Government of India and the Tata Institute of Fundamental Research (TIFR), Mumbai. Indian students participated in all the four Olympiads and returned home with many medals to their credit. A brief report on the Olympiads and the achievements of the Indian students is presented here.

International Chemistry Olympiad 2001

The four-member Indian team performed commendably at the International Chemistry Olympiad, Mumbai, (6 July to 15 July 2001), securing one gold and three silver medals. Soubhagya Sahoo won the gold medal while Vivek Kumar, Avinash Varna and Aditya Banerjee secured silver medals for India.

In terms of aggregate scores, India ranked 7th in the competition. This rank has no official status, as the Olympiads are individual events and not team events. The Chinese team securing 3 Gold and 1 Silver medals topped the competition. A total of 60 countries (54 contesting and 6 observing) participated in this mega event, which had 210 student participants.

The Indian delegation was led by Dr D.V. Prabhu, Wilson College, Mumbai and Dr (Smt.) Leena Rao, SIES College, Mumbai. As HBCSE was the organising institution of the 33rd International Chemistry Olympiad, Mumbai, the Olympiad statues prevented it from training and selection of the final team. The final team was selected at the end of a training camp held at Wilson College, Mumbai in May-June 2001.

The Chemistry Olympiad Programme in India leading to international participation is part of the Integrated National Science Olympiad Programme supported by the Union Ministry of Human Resource Development (MHRD), Department of Science and Technology (DST), Govt. of India and BRNS (Department of Atomic Energy, DAE, Govt. of India). The Homi Bhabha Centre for Science Education (TIFR), Mumbai implemented it this year with Wilson College, University of Mumbai. The first stage of selection process was carried out with the help of Indian Association of Physics Teachers (IAPT).

International Biology Olympiad 2001

The four-member Indian team performed commendably at the International Biology Olympiad, Brussels, Belgium (8 July to 15 July), securing one gold and three silver medals. Preetpaul Singh

Ahluwalia had the distinction of winning the Gold Medal for India. The silver Medal winners for India were Shikar Agarwal, Nilesh Chandra and Namrata Vijayvergia.

The Indian delegation was led by Dr. (Smt.) Bakhtaver S. Mahajan, Homi Bhabha Centre for Science Education, Mumbai and Dr (Smt.) Medha Rajadhyaksha from Sophiya College, Mumbai. The final team was selected at the end of a training camp at the Homi Bhabha Centre for Science Education in June 2001.

The Biology Olympiad Programme in India leading to international participation is part of the Integrated National Science Olympiad Programme supported by MHRD, DST and BRNS (DAE) and is implemented by the Homi Bhabha Centre for Science Education (TIFR), Mumbai. The first stage of selection process is carried out with the help of Indian Association of Physics Teachers (IAPT).

International Physics Olympiad 2001

The five-member Indian team returned with a superb performance at the International Physics Olympiad held in Antalya, Turkey during 28 June – 6 July 2001, securing three gold and two silver medals. Gold medal winners for India were Nandan Dixit, Parag Agrawal and Arvind Thiagrajan while Naresh Satyan and S. Vijay Kumar bagged the silver medals.

In terms of medals, India's performance was on par with the US and Russia who also secured 3 gold and 2 silver medals, and next only to China (4 gold and 1 silver). In terms of aggregate scores, India ranked fourth in the competition. This rank has no official status, as the Olympiads are individual events and not team events.

Prof. Vijay Singh, IIT Kanpur and Dr D.A. Desai, Ruparel College, Mumbai led the Indian delegation. A total of 65 countries with 308 students participated in this world competition. The Physics Olympiad programme in India leading to international participation is supported by BRNS (DAE) and MHRD, and is implemented jointly by the Homi Bhabha Centre for Science Education (TIFR), Mumbai and the Indian Association of Physics Teachers (IAPT).

International Mathematics Olympiad 2001

The six-member Indian team performed commendably at the International Mathematics Olympiad, Washington D.C. (1 July to 14 July 2001), securing two gold, two silver and two bronze medals. Abhav Kumar Jha and Sucharit Sarkar bagged the gold, Abhishek Saha and Samik Basu the silver and Swarmendu Datta and Nikhil Savale the bronze Medals for India at the international meet. In terms of aggregate scores, India ranked 7th in the competition.

The Indian delegation was led by Dr B.J. Venkatachala of the Olympiad Cell (NBHM, DAE) at I.I.Sc., Bangalore and Prof. K.N. Ranganathan of Vivekananda College, Chennai. The Mathematics Olympiad Programme is carried out by the National Board of Higher Mathematics (Department of Atomic Energy). Prof. Rajeev Karandikar of ISI, New Delhi is the National Coordinator of the programme. The final team was selected at the end of a training camp at Homi Bhabha Centre for Science Education, Mumbai from 4 May to 1 June 2001.

(*Source* : HBCSE Website)

Physicists Defy Weakest Link

The newly discovered super conducting material magnesium borate has properties that will have important implications for use as a conductor and a high field generating device.

Research work carried out by Dr David Cardwell and his colleagues at the Cambridge University, UK has revealed that the complex material which behaves like ceramics has qualities that overcome problems many superconductors have—it is not particularly sensitive to the application of a magnetic field. According to Dr Cardwell this is a major breakthrough in this field with exciting implications for potential applications as both a conductor and a high field-generating device.

Until 1987, theory suggested that superconductors could not exist above minus 240°C (approximately 30 K). But a generation of so-called high-temperature superconductors was discovered in 1987 that were developed to superconduct at minus 107°C (166K).

The higher the electrical currents that a superconductor can carry at a given temperature, the greater its potential for use in everyday life. Superconductors are used for a variety of applications including magnetic resonance imaging and energy storage devices that provide a steady power supply for underground and overland trains. Many of the high-temperature superconductors have serious drawbacks. The complex metal oxides are both granular and brittle. When made into wires or other useful materials, it becomes difficult to pass current from one grain to the next.

These grain boundaries are effectively the weak links to the flow of electricity, severely limiting the application potential of the materials. Borate reveals that grain boundaries do not form weak links to the flow of current. The material also overcomes another problem in so much as it appears insensitive to the application of a magnetic field.

(*Courtsey* : Spectrum;
www.ukinindia.com)

Indian Drug Industry Enters a New Era

Hyderabad based Dr Reddy's Laboratory (DRL) has achieved a landmark by developing a new drug to be used for the diabetic patients. The company has awarded the license to manufacture and market the drug to a Swiss company Novartis in May, 2001. This has not been the first time that the Dr Reddy's Laboratory has given a license for a drug developed by it. Dr Reddy's Laboratory gave the license for another drug developed by it to a Danish firm Novo Nordisk about a year ago. Both of the drugs belong to a class of drugs that treat diabetes, hypertension and obesity at the same time.

The development of the drug in itself

may not be a significant event as far as the global scene in this field is concerned. However, it marks the beginning of a new era for the Indian pharmaceutical industry that has been engaged mainly in manufacturing drugs on the licenses received from other countries with little or no research base of its own. Indian drug industry is known for spending very little on research and development activities. Dr Reddy's laboratory, however, has created enough enthusiasm to reverse the trend in future. The laboratory has been able to develop new drugs through its own research and development work, which is no mean achievement in itself.

The guiding spirit behind this success has been a man known as Kallam Anji Reddy, a 59-year old son of a south Indian turmeric farmer, who did his doctoral work at the National Chemical Laboratory in Pune. Although Dr Reddy's Laboratory has been in the field of drug manufacturing for the last two decades or so, an original research programme at the company could be initiated only in 1992. The main driving force for this initiation has been Dr Reddy's desire to get back to the lab. Dr Reddy was awarded Padmashree, a high civilian honour, by the President of India in March this year in recognition of his contribution to the society. Dr Reddy's Laboratory, is also the first Indian drug making company that has been enlisted in the New York Stock Exchange, which shows the confidence reposed on the company by international investors. DRL has also acquired the distinction of being the first Indian drug company to receive license to sell generic drugs in The United States.

Vaccine from Fly Spit

Insect borne diseases have been a major cause of human misery all through the ages. Many vaccine have been developed in the past to protect humans against diseases caused by the infections either carried or directly infused by a variety of insects. In a majority of cases, the antibodies developed in humans or mammals after infecting them with a safe dose of the disease-causing vector are used to develop the vaccine. However, the researchers have now come with an entirely new idea of developing a vaccine against an insect-borne disease derived from the carrier itself rather than the parasite that causes it.

In case the researchers succeed in their initial trials, an injection of fly spit may be as common as any other vaccines at present. It might sounds like medieval quackery, but soon could be the vanguard of modern medicine. Reseachers have used sand fly saliva to develop a vaccine that protects mice against leishmaniasis, a disease spread by the insect. It is based on chemicals that help the fly to feed, preventing blood clotting and dilating blood vessels.

Leishmania, a single-celled protozoon, infects about 12 million people worldwide. Different types of leishmaniasis erode the mucus membranes of the mouth, nose and throat, or internal organs. This latter condition is often fatal.

Jose Ribeiro led the research team for the present study. At present he is working at the National Institute of Allergy and Infectious Diseases (NIAID), Bethesda, Maryland, USA. The focus of present study has been on the skin-attacking Leishmania major, which is spread by the Middle Eastern sand fly *(Phlebotomus papatasi)*.

The research group has found earlier that the bites of uninfected sand flies seem to protect mice from *Leishmania*. Apparently, the same thing applies to people in South America, Africa and around the Mediterranean, where the disease is common. Although mostly newcomers and children get sick, but they may be representing only a small fraction of the people who are actually infected.

In the study a protein was isolated by the research team from the fly's saliva that provoked a particularly strong mouse immune response to *Leishmania*. They then identified the gene for this protein, and injected it into mice. The mouse's cell made the protein from the DNA, triggering their immune response.

Subsequently, the mice was injected with a mixture of fly saliva and *Leishmania*, and it was observed that the mice did not developed any of the symptoms of the disease. They did not eliminate the parasite, but suppressed it to one-hundredth of the level found in untreated mice. According to Riberio, this is similar to the response of humans who are 'immunized' by fly bites.

According to Heidrun Moll, an immunologist at the University of Wurzburg, Germany this is a very promising vaccine candidate. She further observed that although the importance of the carrier in the immune response to insect-borne disease is widely acknowledged, but technical difficulties — such as breeding the insects and keeping them contained — has slowed progress along this direction.

About half a dozen potential *Leishmaniasis* vaccines have been derived from the parasite over the past decade, including one by Moll herself. Eventually, in her opinion people could be immunized using a cocktail of vaccines against both fly and parasite.

According to Riberio different vaccines may have to be developed for different *Leishmania* species based on different species of sand fly because salivary proteins vary a great deal between species. However, this according to him is not likely to pose a big problem as it takes less than two months to go from fly spit to vaccine candidate.

Researchers are also targeting the insects that carry other vaccines. One possible way to fight malaria is to develop vaccines that "do harm" to mosquitoes that suck them up in human blood, asserts Filip Dubovsky of the Malaria Vaccine Initiative in Washington DC, USA. However, as of now there are no candidate malaria vaccines that exploit mosquito saliva.

Drugs to Contain TB

Tuberculosis (TB) is the world's largest single killer responsible for over three million deaths a year. The scientists at Newcastle University, northeast England, are leading an international campaign to prevent TB spreading to

Europe from Africa and Asia. Antibiotics are not always effective against TB because the bacteria have a coating of fatty substances, known as lipids, which acts as a barrier to the drugs. The antibiotics developed at Newcastle combat the antibiotic-resistant strains of TB (which have developed a thicker coating of lipids) that have already killed many people in Africa and Asia and are now a problem in the Baltic States.

Professor Gurdyal Besra, who leads the Newcastle team, said the new drugs could also make treatments against "ordinary" strains of TB much more effective. According to him it has taken 40 years for TB to develop resistance to antibiotics. The research team is aiming to develop completely new types of drugs that might be effective for another 40 years or perhaps even longer. The researchers have already identified a number of potential drugs to combat antibiotic strains of TB, six of which are being tested for their effectiveness and safety. Newcastle University is regarded as one of the world's leading centres for research into anti-TB drugs.

TB was virtually eradicated in the UK in the 1960s with the advent of antibiotics. However, the incidence of TB began rising again in the UK in 1998 where a study showed that 50 per cent of the cases were among people born outside the UK. The disease is still commonplace throughout Asia and Africa where, in the latter continent, the disease has spread rapidly because of the acquired immune deficiency syndrome (AIDS) epidemic, which damages the immune system leaving many more people susceptible.

(*Courtesy* : Spectrum; www.ukindia.com)

Tomatoes that Grow in Salt-rich Soil

Salt in the soil has become a potential threat to vast areas of agricultural land throughout the world. According to some estimates, at present soils that are rich in salt adversely affect farming potential of more than one-third of all irrigated lands worldwide. According to Eduardo Blumwald of the University of California, Davis, USA, minute quantities of salt gets deposited in the soil every time the field is irrigated. The gradual accumulation of salt ultimately renders the land unsuitable for agricultural crops.

Blumwald with a colleague have now genetically modified a traditional crop plant, the tomato, that can thrive in salty water. Besides providing farmers with a cash crop for salted lands, such plants may also take salt out of soils, making it suitable once again for other crops as well. The development may prove to be a potential tool in future in combating the menace of excess salt in the soil.

It may be recalled that while some wild plants flourish in salty conditions, traditional crops become stunted or die when exposed to high concentrations of salts particularly sodium chloride. There are hardly any crops that are salt-tolerant and farmers are left with no choice but to keep their land fallow. Researchers have been struggling for many years to develop breeds of agricultural crops and other already domesticated plants with this trait. Attempts made in this direction by many researchers have not yielded any positive results until now. Their failure left many scientists convinced that salt-tolerance derives from multiple genes.

The first breakthrough, however, came in 1999 when a team of researchers led by Blumwald reported that adding active copies of a single gene normally inactive in the weed *Arabidopsis thaliana* made the plant salt-tolerant. The gene encodes a protein that shuttles sodium into sacs, or vacuoles, inside plant cells, protecting them from salt damage. Salt-tolerant plants use this trick, but in traditional crops this gene seems to have become inactive.

Blumwald has now duplicated his *Arabidopsis* work in the tomato. In the research paper published in the August 2001 issue of the journal *Nature Biotechnology*, he and Hong-Xia Zhang of the University of Toronto have reported that the plant altered by them can grow hydroponically in solutions with sodium chloride concentrations of 200 millimolar (mM). Most crops start dying off at 50 mM salt; seawater contains 530 mM.

The altered tomato plant draws salt from the soil mostly into its leaves, not into its fruit, that according to Blumwald's does not affect the quality of tomatoes. However, while praising Blumwald's work, Clyde Wilson of the US Salinity Laboratory in Riverside, Calif., had cautioned that it might be too early to be optimistic about application of the research findings on a large scale. According to him field-testing of the new plant must demonstrate qualities required for a commercial tomato. The fruit must ripen uniformly, for example, and have tough enough skin for handling. He further added that it is difficult to predict how successful this particular approach will be with other crops, because the tomato has a simple genome compared with many other crops, such as wheat. Blumwald, however, remains confident and had already introduced the salt-tolerance gene into canola, the seeds of which provide a valuable oil. He hopes eventually to further improve plants' salt tolerance to the point where they could be irrigated with seawater. According to him it is not a mere a dream anymore but would prove to be a real possibility in a few years.

Acetaminophen Provides Effective Pain Relief for Migraine Headache

The researchers have found that the headache response rate, that is measured in terms of the transition time from moderate to severe pain at baseline to moderate or absent pain, 2 hours after dosing was 57.8% in the acetaminophen group and 38.7% in the placebo group. Pain-free rates at 2 hours were 22.4% in the acetaminophen group and 11.3% in the placebo group. The mean pain intensity difference from baseline 2 hours after dosing was 1.08 in the acetaminophen group and 0.73 in the placebo group. At 2 hours, other migraine headache characteristics, such as functional disability, photophobia, and phonophobia were significantly improved after treatment with acetaminophen vs placebo.

The authors believe clinical trials are essential for defining safety and efficacy of over-the-counter medications in persons with migraine. According to background information cited in the study, in western countries, it is estimated that 5% to 7% of men and 14% to 19% of women are affected by migraine headaches. About 90% of those with migraine self-treat with over-the-counter (OTC) analgesic medications, and about two-thirds use OTC drugs but do not use any prescription drugs to treat their migraine headaches. The economic cost of migraine per annum is estimated to be quite high because of absenteeism and reduced effectiveness at work. The researchers, therefore, conclude that acetaminophen provides a safe and cost-effective treatment option for many people with migraine and it is available to those who do not seek medical care.

Superconductivity Predicted in New Exotic Materials

Two researchers at Cornell University, USA has predicted that superconductivity could exist at high temperatures in a class of exotic materials containing silver and fluorine. However, none of the materials has yet been made. According to Roald Hoffmann, a chemist at the Cornell University, the hope that these materials might be high-temperature superconductors — that is, capable of conducting electricity with virtually no resistance — is purely theoretical. However, he clarified at the same time that this is not a mere prediction as a plausibility argument but there is really something exciting about it.

It may be recalled that for nearly eighty years after the superconductivity was discovered in 1905, it was believed that this property could exist only in metals at extremely low temperatures, with a maximum transition temperature for its appearance of some 23 K or -250°C. But in 1987, superconductivity was discovered at substantially higher temperatures — 93 K (-180°C) — in cuprate materials. Although low-temperature superconductivity has been explained by the so-called BCS theory (named for John Bardeen, Leon Cooper and Robert Schrieffer), but the high-temperature phenomenon remains essentially unexplained. Since then many new high-temperature superconductors have been discovered. In the year 2000, a metallic compound, magnesium diboride, which had been known for years, was announced by Japanese researchers to be superconducting at nearly 40 K (-233°C).

Although several silver fluorides and many complex fluorides — known as fluoroargentates — are known, none has yet been shown to be a high-temperature superconductor as has been predicted by Hoffmann and his colleagues. A major problem in trying to turn the materials into superconductors is that these fluoroargentates contain silver in unusually high oxidation states (meaning that they are highly deficient in electrons) and thus easily lose elemental fluorine when warmed. Also, since fluorine is the most oxidizing of the elements, it corrodes glass and some other ceramics, probably requiring the use of Teflon or gold containers for large-scale manufacture of the potential superconductors.

Hoffmann, who shared the Nobel Prize for Chemistry in 1981 and is the Frank H.T. Rhodes Professor in Humane Letters at Cornell, and his postdoctoral associate Wojciech Grochala, have presented their theory in a German journal *Angewandte Chemie*. Interestingly, fluoroargentiates bear a strong similarity to oxocuprates, compounds that in 1993 set the record for high-temperature superconducting (minus 109 degrees celcius).

The compounds studied by Hoffmann and Grochala, with names like sodium tetrafluoroargentate the potassium trifluoroargentate, have been known since the 1970s. Hoffmann warns that it will not be easy to exploit the theoretical predictions by actually making the compounds. Despite this, about five laboratories around the world are attempting to produce the proposed superconducting material. The main reason for this uncertainty according to Hoffmann is the fact that despite the efforts of the best minds in physics over the past 15 years, the actual temperature at which the highly unstable material could become superconducting simply cannot be predicted. For these reasons perhaps it remains to be an outstanding unsolved problem in condensed matter theory.

In spite of these scientists are excited about the implications of the predictions made by the researchers and are optimistic to discover materials exhibiting superconductivity at higher temperatures in future.

Platelets can Produce Proteins in Response to Signal

Platelets are one of the major components of the blood that keep floating around in our blood vessels. Platelets are cells lacking in nuclei and their primary function is to stick together so as to repair or plug any puncture or leaks in the blood vessels caused by wounds. In fact platelets serve as ready response troops for containing vessel damage. Since they lack nuclei — the "brains" of cells — platelets are thought of as cellular drones, unable to produce specific proteins in response to signals from other cells.

However, a group of scientists working at the University of Utah, USA have shown that platelets do indeed have the capacity for significant, signal-dependent production of proteins in wound repair and inflammation. The study is a result of an unusual use of the human genome project technology.

Because platelets also participate in disease, the discovery may present opportunities for development of "smart" drugs to treat heart attack, cancer, stroke, hypertension and many other diseases. The researchers have showed that platelets are indeed "armed and dangerous," carrying protein assembly lines that are always ready to proceed as soon as they receive an appropriate signal.

Significantly, a protein produced by these assembly lines is a major player in causing inflammation, a normal response to vessel damage. Usually, cells produce the proteins they need by first transcribing DNA into RNA transcripts and then using the transcript to start an "assembly line" to build the protein. Platelets lack the beginning of the assembly line-nuclei. Instead, the research group found, they have an unusual setup: they carry many RNA transcripts made at an earlier stage in their development, when they do have nuclei. Unexpectedly, some transcripts for proteins are already attached to the ribosome "assembly line", ready to start production at a moment's notice. This setup, called a polysome, allows platelets to produce a significant amount of protein very quickly. Specifically, the research team found that platelets produce interleukin-1-beta (IL-1b), a protein that signals lining cells of damaged vessels to display receptors for white blood cells, key players in inflammation and tissue repair.

This surprising finding indicates that platelets may have a much bigger role than simply stanching blood flow from damaged vessles. The discovery that platelets can, in response to external signals, produce proteins that contribute to repair mechanisms, may prove to be quite significant in understanding their role besides being a major player in managing damaged blood vessels. Since platelets are first to arrive at the scene when vessel damage occurs, their ability to produce signaling proteins that attract white blood cells as well as to plug leaks is medically significant because it offers new insights into ways to influence vessel repair.

The observations may also point the way to strategies for developing more specific, targeted drugs to treat related diseases. In addition to participating in vessel repair, platelets are implicated in many diseases, from heart attacks to peripheral circulation problems causing strokes, gangrene and other complications. By understanding this novel function of platelets, new possibilities arise for treating these diseases.

For example, doctors treating patients with heart attacks might want to inhibit platelet contributions to inflammation, but some of those patients may also have bleeding disorders that would be aggravated by such treatment. With this new information regarding platelet function, drugs could be developed to affect platelets' ability to produce new proteins without impairing their ability to plug holes in injured vessels.

Additionally, the results from this study suggest that platelets may release other physiologically significant protiens — ones that might have roles in tumour growth, hardening of arteries and tissue scarring.

Power from Plastics, Polymer Battery

Researchers at the Johns Hopkins University, USA have developed an all-plastic battery, using polymers in place of the conventional electrode materials. The battery, which is rechargeable and environmentally friendly, has military and space applications and may soon be suitable for small consumer devices, such as hearing aids and wristwatches. The Hopkins project team was asked to create lightweight plastic batteries that could be moulded into almost any size and shape for use in satellites and important military equipment.

The research at Hopkins was supervised by *Theodore O. Poehler* and *Peter C. Searson* both *Professor* in materials Science and Engineering. Along with researches Jeffrey Killian, Hart Sarker and Jossef Gofer, they have produced polymers that can generate up to 2.5 volts in cells that potentially could compete with the 3-volt lithium batteries now on the market. As part of this collaborative effort, engineers at Hopkins' Applied Physics Laboratory, led by Joseph Suter, have been paving the way for practical systems applications by linking the batteries with an innovative solar cell charging system. They also have contributed important technology and fabrication know-how to the project.

The most difficult component of the research and development effort has been to build an all-plastic cell because most polymers that conduct electricity lack sufficient energy difference to serve as electrodes. It is common knowledge that batteries consist of three main component: an anode (the positive electrode), a cathode (the negative one), and an electrolyte (the conductive material between the electrodes). Although other researchers have used a polymer for one of these components, Hopkins scientists are among the first to create a practical battery in which both of the electrodes and the electrolyte are made of polymers.

Laboratory tests have indicated that the Hopkins cells can be recharged and reused hundreds of times without degradation. Yet unlike nickel-cadmium rechargeables, the all-polymer batteries contain no heavy metals, which can contaminate soil and water. The polymer batteries also contain no liquids, which can leak and pose safety hazards.

Another feature of all-plastic battery, according to a team member, is that it operates efficiently in extreme heat or cold unlike the present acid batteries. For example, the car battery, usually lead-acid type, doesn't start well when it's cold. But the properties of the polymer battery would not change even at much lower temperatures that are usually encountered in regions of cold climate. In other words, the polymer batteries would function quite efficiently even in severe winter or in outer space.

In addition, this power cell's unusual thin sandwich design makes it highly adaptable. The anode and cathode are made of thin, foil-like plastic sheets. The electrolyte is a polymer gel film placed between the electrodes, holding the battery together. The cell can be as thin as a business card, although a more power-intensive application would require a larger unit. This thin, flat design could allow battery users to cut a cell to fit a specific space. It enables to make a battery of any desired configuration. For example, one can imagine using it in a large sheet form, to have a battery that may occupy an entire wall, but had very little thickness. Or it could be rolled up into a tube, like AA-size batteries.

These characteristics may be particularly useful in space satellites, where polymer battery sheets could be slipped into crevices without adding much extra weight, according to the researchers. If they were connected to solar cells, the sun's rays could recharge them while the satellite is in orbit.

(*Source* : Internet)

Overweight Girls Tend to Attain Puberty at an Early Age

Researchers have found that young girls who are overweight tend to enter puberty at an earlier age. In a study conducted by Paul Kaplowitz, a pediatrician at the Virginia Commonwealth University School of Medicine, USA, involving nearly 17,000 girls has found an association between heavier-weight girls and early puberty among white girls but the link was less apparent among black girls. Although many people are concerned that girls might feel isolated and different from their peers due to an early maturity, but Kaplowitz dismisses these fears. According to him only in extreme cases, they can end up rather short because if they start growing early, they may be grown up completely by the time they are 10. In his opinion the majority of girls who start puberty between ages 6 and 8 are not at risk of serious psychological or physical problems, and at the most these girls can simply be monitored.

A well-publicised study published four years ago in Pediatrics showed American children were attaining puberty earlier than they did in previous decades, and that black girls reached puberty about a year earlier on average than whites. Other studies have suggested that the bodies of heavier-weight girls may reach puberty earlier because they have more of a type of proteins called leptins, which are thought to trigger hormone releases that cause pubic hair to grow and breasts to form.

Marcia Herrman-Giddens of the University of North Carolina at Chapel Hill School of Public Health, USA, who has published the results of her study in 1997, observes that 30 or 40 years ago, the decline in the age of attaining puberty was explained by better nutrition and less infectious disease. Now we are beyond that point and have about a quarter of the US children who are either overweight or obese, which is definitely unhealthy. The latest growth data in the USA shows that both boys and girls are getting their growth spurts earlier now than they were 30 or 40 years ago. According to her if environmental conditions are influencing girls to develop earlier than they used to, we ought to try to find out what they are because they are not likely to be healthy.

It may be not out of place to mention that in India also obesity in young particular amongst those belonging to the affluent and the upper middle class families is on the rise.

Long-Distance Anti-Crime Camera

A revolutionary open circuit television (OCTV) camera, which beams video pictures to personal computers and laptops via a mobile phone network, has been developed by an electronic company in the United Kingdom. The system has been adopted by more than

20 police forces throughout the UK for surveillance purposes that costs 80 per cent less than conventional closed-circuit-television (CCTV) surveillance packages. The small camera in the system has no wires and can send or receive high quality pictures over any distance.

According to a spokesperson of the company that has developed the system, the camera system can cost between 500 and 3,000 pounds sterling, depending on the size of its hard drive and mobile phone that transmits encrypted pictures to remote devices, which can be up to 20,000 kilometres away. The camera has enough memory for two months of recorded images. The more expensive systems enable footage to be stored on a digital versatile disk (DVD). Held in the palm of the hand, bolted to the wall or installed in a ceiling, the camera can pan, tilt or zoom and also respond to remote control.

The images are quite sharp and can be produced as an evidence against criminals in the court. Police and other law-enforcement officers can carry a palm-sized computer in their pocket with a mobile phone on their belt and a camera as big as a cigarette lighter on their lapel to collect evidence, just like a secret agent in a crime film. The manufacturers of the system claim that one could sit in a hotel room in Hong Kong or UK and watch via a mobile phone his home located in the New Delhi or Mumbai. The system makes use of the vastly improved third-generation technology camera that has enormous potential not only for surveillance purposes but also for monitoring departmental stores, schools and homes.

Encrypted transmissions prevent unauthorised viewers gaining access to the material. A personal' code enables mobile phone monitoring from any part of the world and the company claims there is no loss in picture clarity. The implications are far reaching — not least in terms of personal privacy — for their is no effective way OCTV can be monitored, censored or controlled by any other agency.

(*Courtesy* : Spectrum;
www.ukindia.com)
Compiled and edited by
R. Joshi

Book Review

Chandrasekhar and His Limit

Book Reviewed : **Chandrasekhar and his Limit;** *Author* : **G. Venkataraman;** *Publisher* : **University Press (India) Ltd., 3-5-820, Hyderguda, Hyderabad-500029, pp. 139; Price Rs. 40**

THE 'Chandrasekhar limit' is a discovery of great significance in astrophysics. However, this discovery by the great genius Subrahmanyan Chandrasekhar became possible only after lot of painstaking effort and perseverance. Even after making the discovery Chandrasekhar had to struggle a lot for its acceptability. He had to face the criticism of the then doyen of astronomy, the famous Cambridge astrophysicist Arthur Eddington who ridiculed his theory. Eddington almost shattered the edifice on which his theory rested by dubbing it as 'stellar buffoonery'.

But, this encounter of Chandrasekhar with Eddington proved to be a blessing in disguise. Had Eddington not opposed him what would have been the outcome ? Speculating on this Chandrasekhar, after lot of soul searching, had made the following inspiring remarks, "My position in science would have been radically altered as of that moment. Eddington's praise could make one very famous in astronomy. But I really do not know how I would have reacted to the temptation, to the glamour. How many young men after being successful and famous have survived for long periods of time?"

However, one can really appreciate Chandrasekhar, for, in spite of all this he did not severe his links with Eddington. Even after having shifted to American from Cambridge he kept on exchanging letters with Eddington. After the death of Eddington in 1944 Chandrasekhar delivered a memorial speech at the University of Chicago. Speaking on the occasion he said, "I believe that anyone who has known Eddington would agree that he was a man of the highest integrity and character. I do not believe, for example, that he ever thought harshly of anyone. That was why it was so easy to disagree with him on scientific matters". This only brings forth yet another facet of the personality of the great astrophysicist Chandrasekhar.

In 1982, when Chandrasekhar was invited by the Cambridge University to deliver a series of lectures on the occasion of Eddington's centenary he had again but all praise for Eddington. For Chandrasekhar the disappointment of the past was over a long, long time ago.

So, Chandrasekhar was not only a distinguished astrophysicist but also a person with high human qualities. Serving science needs human angle very much for ultimately the fruits of science have to reach the common masses for the betterment of their quality of life. Lives of great scientists like Chandrasekhar always motivate not to lose sight of this cherished objective behind doing science.

Chandrasekhar worked on various problems. However, the book under review concentrates mostly on the discovery of the Chandrasekhar limit. The book starts with some narratives about young Chandra. While in school Chandra excelled in studies, his favourate subject being mathematics. Strangely, Chandrasekhar did not attend kindergarten or elementary school. Straightaway he was adimitted to standard four (equivalent of today's sixth standard) in the Hindu High School, Madras. After completion of school education, Chandrasekhar entered the Presidency College, Madras where his uncle C.V. Raman had studied two decades earlier.

There is a very interesting story about Raman which goes like this. In 1922 after having returned from his first foreign visit from England, Raman visited his brother C.S. Iyer and his family. When Raman was narrating his experiences abroad a young boy among the audience, who was none else than Chandra, suddenly asked, "Did you find it embarrassing to go around London wearing a turban". Of course, Raman took his question amusingly and gave a satisfactory reply to satiate the curiosity of the young questioner.

Looking at the stars for ages the astronomers have been able to accumulate a wealth of data. All this has, as a matter of fact, been largely the outcome of observational astronomy.

A star is nothing but a cosmic gaseous cloud held in equilibrium by two opposing forces—gravity and pressure. The pressure is mainly generated by the thermonuclear burning that goes on inside the star. After taking birth a star ages, going through its evolutionary process. However, when the star finally runs out of fuel it stops burning. The star now starts shrinking. Does the process go on for ever or the shrinking of the star stops somewhere ? The answer to this question first came in 1927 from the English astrophysicist R.H. Fowler who said that when the star has collapsed to a small size, a new kind of pressure, called degeneracy pressure, is produced due to the quantum mechanical effects. The shrinking of the star is, therefore, arrested at this stage and it turns into a white dwarf.

The Fowler's contribution was hailed by the scientific community. However, Chandrasekhar created a sensation by saying that the formation of white dwarf was not an absolute rule. By analyzing the problem more carefully Chandrasekhar showed that if the initial mass of the star (that is, the mass of the star at the time it started shrinking) is less than 1.4 times the solar mass then it would eventually pass into the white dwarf stage. However, if the initial mass exceeded 1.4 times the solar mass then the star would not become a white dwarf. With the initial star mass equivalent to 1.4 times the solar mass (this is in fact what the famous Chandrasekhar limit is) the resultant white dwarf would have zero radius.

This was interpreted to be a very bizarre result indeed. It even generated heat of controversy between Chandrasekhar and Eddington. The latter literally ridiculed him by saying, "Your mathematics may be all right but I don't think your physics is correct".

Eddington did not stop at that. He even went to the extent of humiliating Chandrasekhar in the meeting of the Royal Astronomical Society held in London in January, 1935 in which both spoke presenting papers on their findings.

In fact what Fowler had applied was non-relativistic approach (valid for speeds much too small compared to the speed of light) in conjunction with quantum statistical mechanics to the dense matter of white dwarf. Being in such a highly dense state, matter no longer will contain atoms as we know them. The atoms, in fact, would all have been crushed and so there would be nothing but electrons and nuclei.

Chandrasekhar questioned Fowler's approach by saying that since under white dwarf condition the electrons would have enormous velocities (approaching the velocity of light), relativity physics would have to be applied. So, by viewing white dwarf as a relativistic degenerate matter Chandrasekhar concluded that for a limiting mass (which is 1.4 times the solar mass) even degeneracy pressure cannot arrest collapse of the star to a point. In fact, Chandrasekhar applied both Pauli's exclusion principle and relativity theory to arrive at the novel concept of Chandrasekhar limit.

Chandrasekhar published his findings in the form of a book. The book titled 'An Introduction to the Study of Stellar Structure' was published in 1937 by the University of Chicago.

Soon the book became famous and so did Chandrasekhar himself. People no longer seemed to bother about Eddington's objection. So Chandra's theory was finally accepted. This indeed was the triumph of pure thought.

However, Chandrasekhar had left unanswered the question : "What would happen if a star with a mass greater than 1.4 times the solar mass were to run out of fuel and start shrinking ?" This was, in fact, one of the questions raised by Eddington himself. Chandrasekhar had only said that it would not pass into the white dwarf stage. Nobody, why alone Chandrasekhar, could have answered the question at that time because many facts needed for giving the exact, precise answer were not known till then. Now, of course, we know that a star with mass greater than the Chandrasekhar limit would end up either as a neutron star or as a black hole. As is well known now, a black hole is an extremely compact and massive object which has such a powerful gravitational field that nothing, not even light, can escape it.

The fascinating account of the discovery of Chandrasekhar limit has been brought home in the book under review. This will stimulate young minds and will create an interest in them for science in general and physics in particular. The book will specially benefit the graduate and post-graduate students of both physics and astrophysics.

Besides his significant contributions in astrophysics (and some other branches of physics as well) Chandrasekhar had authored five books. After publication of his first book on stellar structure his second book entitled 'Principles of Stellar Dynamics' was published in 1942. His next book 'Radiative Transfer' came out in 1950. This was followed by 'Ellipsoidal Figures of Equilibrium' that was published in 1969. Chandrasekhar's fifth book was on black holes. Entitled 'The Mathematical Theory of Black Holes' the book was published in 1983, the year when he got the Nobel Prize (the award was incidentally announced on 19 October, his birthday). In addition, Chandrasekhar has also authored a book 'Truth and Beauty — Aesthetics and Motivations in Science' which is a collection of various lectures delivered by him at different points of time. Chandrasekhar was not for material beauty but he was after what he called 'mathematical beauty'. He saw 'aesthetic beauty and the aesthetic sensibility' in Einstein's general theory of relativity.

It was the 'beauty' of his inner self that endowed him with such a personality and totally unassuming and down-to-earth nature. The book under review includes some nice anecdotes about his simple disposition. Once while in Chicago Prof. Auluck of Delhi University wanted to see him. So he telephoned him. To Prof. Auluck's surprise he was willing to meet him straightaway even though it was quite late at night. And indeed Chandrasekhar greeted his Indian visitor with a smile when the latter went to meet him.

There is another story which goes like this. Once a sister-in-law of Chandrasekhar wanted to buy him a present. "Buy me a pencil" said Chandrasekhar instantly adding, "this is the only thing I use". Who will not marvel at such simplicity !

Chandrasekhar used to drive from Yerkes Observatory to Chicago University to teach two of his brilliant students Lee and Yang (who incidentally became Nobel laureates much before him, in 1957). Once, while on the way to Chicago, he was caught in a bad snow storm. The conditions were so unfavourable that everybody had abandoned driving and took shelter. But, Chandrasekhar was not to be cowed down. He kept on driving with the firm determination to reach for his class on time.

Chandrasekhar had high regards for the great mathematician Srinivasa Ramanujan (who died when Chandra was a young boy). Nobody can believe the story but Chandrasekhar was instrumental in arranging for a photograph of Ramanujan. It all happened when the British mathematician G.H. Hardy (who did much to help Ramanujan) wanted to publish a book on Ramanujan and his work. The book was an outcome of the lectures that Hardy had earlier delivered in 1936 at the American Harvard University.

Hardy wanted a photograph of Chandrasekhar for inclusion in the book. But no such photograph was available. In desperation Hardy approached Chandrasekhar who was then in Cambridge. To help Hardy, Chandrasekhar personally visited Madras and collected

Ramanujan's latest passport photo, the only one that was left with Smt. Ramanujan till then.

The bibliographical account of Chandrasekhar has been nicely included in the concluding chapter of the book. Certainly, a 'must-read' and inspiring book that will specially motivate the young readers for taking up careers in science.

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DNA Fingerprinting

Approaches, Applications and Problems in Forensic Chemistry

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This paper will give you the basic information on the structure and function of DNA as it relates to DNA fingerprinting. This topic is especially pertinent in today's society because of the rising use of DNA fingerprinting as evidence in court cases.

Chemistry of DNA

DNA (Deoxyribonucleic acid) is a chemical structure that forms chromosomes. A piece of a chromosome that dictates a particular trait is called a gene. Structurally, DNA is a double helix: two strands of genetic material spiraled around each other. Each strand contains a sequence of bases (also called nucleotides). A base is one of four chemicals (adenine, guanine, cytosine and thymine). The two strands of DNA are connected at each base. Each base will only bond with one other base, as follows: Adenine (A) will only bond with thymine (T), and guanine (G) will only bond with cytosine (C). Suppose one strand of DNA looks like this:

A-A-C-T-G-A-T-A-G-G-T-C-T-A-G

The DNA strand bound to it will look like this:

T-T-G-A-C-T-A-T-C-C-A-G-A-T-C

Together, the section of DNA would be represented like this:

T-T-G-A-C-T-A-T-C-C-A-G-A-T-C
A-A-C-T-G-A-T-A-G-G-T-C-T-A-G

DNA strands are read in a particular direction, from the top (called the 5' or 'five prime' end) to the bottom (called the 3' or 'three prime' end). In a double helix, the strands go opposite ways:

5' T-T-G-A-C-T-A-T-C-C-A-G-A-T-C3'
3' A-A-C-T-G-A-T-A-G-G-T-C-T-A-G5'

What is DNA Fingerprinting?

The chemical structure of everyone's DNA is the same. The only difference between people (or any animal) is the order of the base pairs. There are so many millions of base pairs in each person's DNA that every person has a different sequence. Using these sequences, every person could be identified solely by the sequence of their base pairs. However, because there are so many millions of base pairs, the task would be very time-consuming. Instead, scientists are able to use a shorter method, because of repeating patterns in DNA. These patterns do not, however, give an individual 'fingerprint' but they are able to determine whether two DNA samples are from the same person, related people, or non-related people. Scientists use a small number of sequences of DNA that are known to vary among individuals a great deal, and analyze those to get a certain probability of a match.

How is DNA Fingerprinting Done?

Performing a Southern Blot: The Southern Blot is one way to analyze the genetic patterns which appear in a person's DNA. Performing a Southern Blot involves: (i) Isolating the DNA in question from the rest of the cellular material in the nucleus. This can be done either chemically, by using a detergent to wash the extra material from the DNA, or mechanically, by applying a large amount of pressure in order to 'squeeze out' the DNA. (ii) Cutting the DNA into several pieces of different sizes. This is done using one or more restriction enzymes. (iii) Sorting the DNA pieces by size. The process by which the size separation, 'size fractionation', is done is called gel electrophoresis. The DNA is poured into a gel, such as agarose, and an electrical charge is applied to the gel, with the positive charge at the bottom and the negative charge at the top. Because DNA has a slightly negative charge, the pieces of DNA will be attracted towards the bottom of the gel; the smaller pieces, however, will be able to move more quickly and thus further towards the bottom than the larger pieces. The different-sized pieces of DNA will, therefore, be separated by size, with the smaller pieces towards the bottom and the larger pieces towards the top. (iv) Denaturing the DNA, so that all of the DNA is rendered single-stranded. This can be done either by heating or chemically treating the DNA in the gel. (v) Blotting the DNA. The gel with the size-fractionated DNA is applied to a sheet of nitrocellulose paper, and then baked to permanently attach the DNA to the sheet. The Southern Blot is now ready to be analyzed. In order to analyze a Southern Blot, a radioactive genetic probe is used in a hybridization reaction with the DNA in question. If an Xray is taken of the Southern Blot after a radioactive probe has been allowed to bond with the denatured DNA on the paper, only the areas where the radioactive probe binds will show up on the film. This allows researchers to identify, in a particular person's DNA, the occurrence and frequency of the particular genetic pattern contained in the probe.

Making a Radioactive Probe : (i) Obtain some DNA polymerase. Put the DNA to be made radioactive (radiolabeled) into a tube. (ii) Introduce nicks, or horizontal breaks along a strand, into the DNA you want to radiolabel. At the same time, add individual nucleotides to the nicked DNA, one of which, is radioactive. (iii) Add the DNA polymerase to the tube with the nicked DNA and the individual nucleotides. The DNA polymerase will become immediately attracted to the nicks in the DNA and attempt to repair the DNA, starting from the 5' end and moving toward the 3' end. (iv) The DNA polymerase begins repairing the nicked DNA. It destroys all the existing bonds in front of it and places the new nucleotides, gathered from the individual nucleotides mixed in the tube, behind it. Whenever a G base is read in the lower strand, a radioactive base is placed in the new strand. In this fashion, the nicked strand, as it is repaired by the DNA polymerase, is made radioactive by the inclusion of radioactive bases. (v) The nicked DNA is then heated, splitting the two strands of DNA apart. This creates single-stranded radioactive and non-radioactive pieces. The radioactive DNA, now called a probe, is ready for use.

Creating a Hybridization Reaction : (i) Hybridization is the coming together, or binding of two genetic sequences. The binding occurs because of the hydrogen bonds between base pairs. Between a A base and a T base, there are two hydrogen bonds; between a C base and a G base, there are three hydrogen bonds. (ii) When making use of hybridization in the laboratory, DNA must first be denatured, usually by using heat or chemicals. Denaturing is a process by which the hydrogen bonds of the original double-stranded DNA are broken, leaving a single strand of DNA whose bases are available for hydrogen bonding. (iii) Once the DNA has been denatured, a single-stranded radioactive probe can be used to see if the denatured DNA contains a sequence similar to that on the probe. The denatured DNA is put into a plastic bag along with the probe and some saline liquid; the bag is then shaken to allow sloshing. If the probe finds a fit, it will bind to the DNA. (iv) The fit of the probe to the DNA does not have to be exact. Sequences of varying homology can stick to the DNA even if the fit is poor; the poorer the fit, the fewer the hydrogen bonds between the probe and the denatured DNA. The ability of low-homology probes to still bind to DNA can be manipulated through varying the temperature of the hybridization reaction environment, or by varying the amount of salt in the sloshing mixture.

Variable Number Tandem Repeats

Every strand of DNA has pieces that contain genetic information which informs an organism's development (exons) and pieces that, apparently, supply no relevant genetic information at all (introns). Although the introns may seem useless, it has been found that they contain repeated sequences of base pairs. These sequences, called Variable Number Tandem Repeats (VNTRs), can contain anywhere from twenty to one hundred base pairs. Every human being has some VNTRs. To determine if a person has a particular VNTR, a Southern Blot is performed, and then the Southern Blot is probed, through a hybridization reaction, with a radioactive version of the VNTR in question. The pattern which results from this process is what is often referred to as a DNA fingerprint. A given person's VNTRs come from the genetic information donated by his or her parents; he or she could have VNTRs inherited from his or her mother or father, or a combination, but never a VNTR either of his or her parents do not have. Because VNTR patterns are inherited genetically, a given person's VNTR pattern is more or less unique. The more VNTR probes used to analyze a person's VNTR pattern, the more distinctive and individualized that pattern, or DNA fingerprint, will be.

Practical Applications of DNA Fingerprinting

Paternity and Maternity : Because a person inherits his or her VNTRs from his or her parents. VNTR patterns can be used to establish paternity and maternity. The patterns are so specific that a parental VNTR pattern can be reconstructed even if only the children's VNTR patterns are known (the more children produced, the more reliable the reconstruction). Parent-child VNTR pattern analysis has been used to solve standard father-identification cases as well as more complicated cases of confirming legal nationality and, in instances of adoption, biological parenthood.

Criminal Identification and Forensics : DNA isolated from blood, hair, skin cells, or other genetic evidence left at the scene of a crime can be compared, through VNTR patterns, with the DNA of a criminal suspect to determine guilt or innocence. VNTR patterns are also useful in establishing the identity of a homocide victim, either from DNA found as evidence or from the body itself.

Personal Identification : The notion of using DNA fingerprints as a sort of genetic bar code to identify individuals has been discussed, but this is not likely to happen anytime in the foreseeable future. The technology required to isolate, keep on file, and then analyze millions of very specified VNTR patterns is both expensive and impractical. Social security numbers, picture ID, and other more mundane methods are much more likely to remain the prevalent ways to establish personal identification.

Problems with DNA Fingerprinting

Like nearly everything else in the scientific world, nothing about DNA fingerprinting is cent per cent assured. The term DNA fingerprint is, in one sense, a misnomer: it implies that, like a fingerprint, the VNTR pattern for a given person is utterly and completely unique to that person. Actually, all that a VNTR pattern can do is present a probability that the person in question is indeed the person to whom the VNTR pattern (of the child, the criminal evidence, or whatever else) belongs. Given, that probability might be 1 in 20 billion, which would indicate that the person can be reasonably matched with the DNA fingerprint; then again, that probability might only be 1 in 20, leaving a large amount of doubt regarding the specific identity of the VNTR pattern's owner.

Generating a High Probability

The probability of a DNA fingerprint belonging to a specific person needs to be reasonably high—especially in criminal cases, where the association helps establish a suspect's guilt or innocence. Using certain rare VNTRs or combinations of VNTRs to create the VNTR pattern increases the probability that the two DNA samples do indeed match (as opposed to look alike, but not actually come from the same person) or correlate (in the case of parents and children).

Problems with Determining Probability

Population Genetics : VNTRs, because they are results of genetic inheritance, are not distributed evenly across all of human population. A given VNTR cannot, therefore, have a stable probability of occurrence; it will vary depending on an individual's genetic background. The difference in probabilities is particularly visible across racial lines. Currently, not enough is known about the VNTR frequency distributions among ethnic groups to determine accurate probabilities for individuals within those groups; the heterogeneous genetic composition of interracial individuals, who are growing in number, presents an entirely new set of questions. Further experimentation in this area, known as population genetics, has been surrounded with and hindered by controversy, because the idea of identifying people through genetic anomalies along racial lines comes alarmingly close to the eugenics and ethnic purification movements of the recent past, and, some argue, could provide a scientific basis for racial discrimination.

Technical Difficulties : Errors in the hybridization and probing process must also be figured into the probability, and often the idea of error is simply not acceptable. Most people will agree that an innocent person should not be sent to jail, a guilty person allowed to walk free, or a biological mother denied her legal right to custody of her children, simply because a lab technician did not conduct an experiment accurately. When the DNA sample available is minuscule, this is an important consideration, because there is not much room for error, especially if the analysis of the DNA sample involves amplification of the sample (creating a much larger sample of genetically identical DNA from what little material is available), because if the wrong DNA is amplified (i.e. a skin cell from the lab technician) the consequences can be profoundly detrimental. Until recently, the standards for determining DNA fingerprinting matches, and for laboratory security and accuracy which would minimize error, were neither stringent nor universally codified, causing a great deal of public outcry.

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TERMS TO REMEMBER

Base pairs: A set of two bonded nucleotides on opposite strands of DNA. There are two possible base pairs: C-G and A-T.

Chromosome: A rod-like structure of tightly coiled DNA found in the cell nucleus of plants and animals. Chromosomes are normally found in pairs: human beings typically have 23 pairs of chromosomes.

DNA polymerase: An enzyme which repairs DNA by facilitating the formation of hydrogen bond between a nucleotide on a broken piece of DNA, such as a nicked or single-stranded piece of DNA as created in the laboratory, and the individual nucleotide it needs to form a complete and stable base pair.

Gene: A section of a chromosome, made up of DNA. A given gene provides the information a cell needs to create a specific protein. Collectively, the genes of an organism inform, to some extent, nearly every aspect of the development and formation of that organism. Genes do not, however, dictate behaviours or traits, and neither are genetically informed behaviours and traits incapable of being modified or supplanted; environmental factors also play a very important part in influencing the organism's development and formation.

Homology: The degree to which two pieces of DNA match, or complement each other (two pieces of DNA are complementary if their respective nucleotides, in their current order, match C to G and A to T). If one piece of DNA is 100% complementary to another piece of DNA, they demonstrate very high homology; if the pieces are only able to form a handful of base pairs between their corresponding nucleotides, they demonstrate very low homology.

Hybridization Reaction: A process in which a probe binds to a Southern Blot if the probe's DNA sequence and the DNA on the Southern Blot match.

Nucleus: The center of a cell, where all of the DNA, packaged in chromosomes, is contained.

Probe: A radioactive strand of DNA often used to find particular sequences in a Southern Blot.

Restriction enzyme: An enzyme normally found in bacteria which cuts DNA at specific sites (i.e. each time a specific nucleotide pattern occurs). Because a restriction enzyme always acts upon DNA in the same manner, a map can be made of a restriction enzymes actions on a known set of nucleotides.

Trait: The physical manifestation of the information on a gene. If a gene contains the information needed by the organism to create purple eyes, for example, the fact that the organism did indeed have purple eyes is considered a trait of that organism.

The Big Bang and the Universe

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We are naturally curious to know about the universe we live in. The questions that often arise in contemplating the universe at large are: How did the universe evolve? How old is it and what is its ultimate fate? How did the galaxies and stars form? How matter was created?

The questions regarding the origin, evolution and future behaviour of the universe come under the realm of cosmology which is the scientific study of the large-scale structure of the universe as a whole. Many theories regarding origin of the universe, namely, big-bang, steady state and oscillating universe theories have been put forth by the scientists. Of these, the big-bang theory has so far been most accredited by the scientists. According to this theory, the universe evolved with a violent explosion around 15 billion years ago. The whole universe was very hot and compact (or dense) when a 'big-bang' happened. Due to the violent explosin, the big-bang, the matter was broken into fragments which were thrown in all directions forming the galaxies and starts. The explosive kinetic energy of the big-bang, therefore, led to an expanding universe.

In 1929 Edwin Hubble, an American astronomer, found that the absorption lies in the spectra of some of the galaxies showed *red-shift*. This meant that these galaxies were shifted toward the red end. If λ be the observed wavelength and λ the expected or crue wavelength (assuming the galaxy to be stationary), then the red-shift Z is given by

$$Z = (\lambda - \lambda_0) / \lambda_0$$

Obviously, when the observed wavelength (λ) exceeds the true wavelength (λ_0), has a positive value suggesting λ red shift.

The red-shift of galaxies can be interpreted as arising from Doppler effect. First discovered by the Dutch scientist Doppler for sound waves, the Doppler effect essentially is a basic property of waves and is, therefore, naturally expected to occur for light waves also. It may be mentioned that besides dopper red-shift gravitational red-shift (in which the cause of red-shift is gravity) may also be observed. However, as the latter is based on the involved concepts of General Theory of Relativity evolved by Einstein, it will not be discussed here.

It can be shown that the red shift, if small compared to unity, is given by the velocity of recession (of galaxies) to the velocity of light:

$$z = v / c$$

The red-shift of galaxies showed that they were rushing away from us with enormous speeds. It demonstrated that we are living in a non-static expanding universe.

Hubble also found that the red-shift z of a galaxy increases with its distance D from us according to the formula

$$v = cz = HD$$

where H is a constant known as Hubble's constant. This is known as Hubble's law which states that the recession velocity of a galaxy is proportional to its distance from us. According to Hubble's law, a galaxy which is twice as far away as another is moving away from us at twice the speed. Similarly, a galaxy three times as far away is travelling three times as fast, and so on. Today, this law is known to hold true for galaxies at a distance of at least several billion light years away from us.

Cosmic Microwave Background (CMB) Radiation

A faint glow from the birth pangs of the universe had been predicted in 1940s by George Gamow, a Russian-American physicist who was also an outstanding popular science writer. Gamow argued that the big-bang must have been accompanied by the emission of radiation. A faint remnant of this radiation, called the cosmic background radiation, must be present today in the microwave range. Indeed, this remnant radiation was discovered, and quite by accident, in 1965 by Arno A. Penzias and Robert W. Wilson at the Bell Telephone Laboratories, Holmdel, New Jersy. Penzias and Wilson were both working at the microwave wavelength of 7.35 cm with the help of a 20-feet (6 m) horn reflector antenna originally designed for satellite communication to monitor radio emissions from a ring of gas encircling the Milky Way Galaxy. While calibrating their equipment, the two radio astronomers detected an unexpected background 'noise'. This result surprised them very much. They thought that probably due to some snag in their detector the unexpected result had been obtained. On careful observation they found bird droppings on their detector. They removed it and also checked their instrument thoroughly. However, the noise still refused to go away. More astonishing was the fact that the noise was being received from all the directions. Soon they realised that they had been able to detect the remnant radiation from the big-bang. The intensity of radiation indicated a temperature of 3.5 K.

The cosmic microwave background (CMB) radiation detected by Penzias and Wilson confirmed the big-bang theory. This experimental confirmation is one of the most important findings of the 20th century. Penzias and Wilson were, therefore, jointly honoured in 1978 with a Nobel prize is physics.

In 1992, the instruments a board cosmic Background Explorer (COBE), a satellite of NASA that was launched in November 1989 from Vandenberg Air Force Base, California, detected tiny fluctuations, or anisotropy, in the temperature of the cosmic microwave background radiation, the residual rediatich left over from the Big-Bang. In a particular direction, the temperature of the radiation was found to be 2.7251 K while in another direction it was 2.7249 K. Thus, a difference of

0.002 K between two measurements taken in different directions was observed by COBE. These fluctuations in the temperature, which were related to the fluctuations in the density of matter in the early universe, were anxiously expected by astronomers since these are the necessary "seeds" around which matter must have condensed due to gravity, and which gave rise to structures that eventually evolved into cosmic structures such as galaxies, stars, clusters and voids.

To study the fluctuations in the microwave background radiation, NASA launched a probe called Microwave Anisotropy Probe (MAP) with the help of a Delta II rocket on 30 June 2001. The newly sent probe MAP is specially designed to have an accuracy of one-millionth of a degree. As compared to this, COBE had only an accuracy of one ten-thousandth of a degree. The angular resolution of MAP is also much higher than COBE. To achieve the desired angular resolution, MAP has been provided with a set of passively cooled microwave radiometers with primary reflectors having diameter of 1.4 × 1.6 metre. The MAP is, therefore, fully equipped to scan the fluctuations in the temperature of the CHB radiation with much higher resolution, sensitivity and accuracy than COBE.

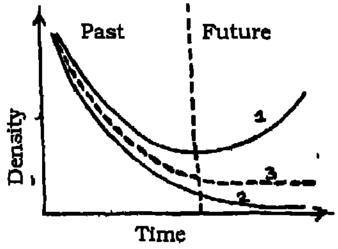
The improved details of the CMB radiation obtained by MAP will help astronomers answer the fundamental questions about the history, content, shape and fate of the universe. It will also shed light on the process by which the galaxies and other structures formed in the universe. The MAP will finally reach an orbit around the so-called L2 Lagrange point (of the Sun-Earth system) which is about 1.5 million kilometres from Earth. From L2 orbit, MAP will have an unobstructed view of the sky, and will be free from near-Earth disturbances such as magnetic fields and microwave emissions for its two years of science observations. This particular orbit for MAP is actually designed to minimise the use of fuel. The observations of MAP, hope the astronomers, will definitely further our understanding of cosmology.

Fate of the Universe

If we believe that the universe is expanding then what, after all, is going to be the fate of the universe? Will it keep on expanding for every or will it ever stop expanding? In this context one should not lose sight of the fact that the universe has to expand overcoming the gravitational field that is provided by the entire mass-energy content of the universe. This gravitational attraction acts like a cosmic brake which tries to oppose the expansion. The deceleration rate is determined by the average matter density of the universe.

If the average matter density happens to be smaller than a critical value (of 7×10^{-27} kg/m^3) then the galaxies will never come to a halt. In this scenario, called the *open universe*, the universe will expand for ever with a stars, galaxies etc. slowly dying out. On the other hand, if the average density is greater than the critical density, the universe will expand to a maximum limit and then contract. In this situation, the universe will come to a standstill and then will turn back on itself, and finally end up in a *big crunch*. However, because of the uncertainties in the density estimates we do not have a definitive answer today about the fate of the universe. It is know, however, that the density is not far way from the critical value. Obviously, if the density were too high, the universe would have collapsed long ago. If, on the other hand, the density were much smaller than the critical value, then the galaxies would have dispersed already allowing no time for the slow evolution needed for the wonderful development of the phenomenon of life. However, only the future observational results will be able to resolve this tantalizing question.

The celebrated British cosmologist Stephen Hawking has visualized the picture of a universe that is finite having no boundary or edge. This novel idea of a finite universe has been nicely described by Hawking in his best seller science book *A Brief History of Time*.



Three models of the cosmological expansion:

1. **The density of the Universe is greater than the critical density;**
2. **The density of the Universe is less than the critical density;**
3. **The density fo the universe equals the critical density.**

Besides, propounding theories about the origin and the fate of the universe, the scientists are also attempting to create particles with higher and higher energies in the laboratory so that they could simulate conditions prevailing at the earliest stages of the evolution of the universe. To achieve this goal, mammoth particle accelerators are being pressed into service by the physicists.

Recently, the scientists at the Brookhaven National Laboratory (USA) have been able to create the highest density of matter ever produced in an experiment. Using a highly energetic particle accelerator called 'Relativistic heavy Ion Collider', the scientists accelerated the nuclei of gold atoms to nearly the speed of light. These highly energetic nuclei were then made to collide with each other. Studying the debris streaming from the collisions, the scientists concluded that densities more than twenty times higher than those prevalent within the nuclei of ordinary matter (which is around 2.3×10^{13} kg/m^3) had been created. The temperature of this highly condensed matter was found to be a staggering 1 trillion (10^{12}) degrees.

The Brookhaven scientists said that their results on the matter density, if proved, confirmed, would indicate that they had been able to create matter having density twice as much as reported by the Geneva-based CERN Laboratory, last year. The results may shed light on the birth of the universe as also on what goes on at the centres of dense and exploding stars.

Traffic Pollution

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Human brain with a capacity of around 1400cc has altered the environment according to his comforts and needs. In doing so, he has endangered the whole life-supporting system. One such glaring example of over-indulgence is the destruction of our environment with poisonous gases and particulate matter thrown out by traffic exhaust. In most of the mega metropolitan cities of the world, air and noise pollution from motor vehicles are fast becoming major problems for physical and mental health of the people. The young and old are more susceptible to the toxic effects of vehicle exhaust. Motor vehicle exhaust is a complex mixture of a complex mixture, the composition of which depends on the fuel type, operating condition of the engine, and the use of an emission control device. Motor vehicles increase pollution by adding carbon monoxide, nitrogen oxide, unburnt hydrocarbons, ozone, lead, benzene, acidic fumes, and other photochemical oxidants and, in smaller quantities, total suspended particulate, sulphur dioxide and volatile organic compounds. All these pollutants have synergistic and additive effects on human health and cause premature ageing of lungs in the long run. As a result of this those who are living in big metros for 10-15 years are having black lungs while our villagers are having pinkish lungs. Pollutants and their derivatives interact with and impair the molecules crucial for the normal functioning of physiological processes of human body hence produce adverse effects.

Exposure to vehicle pollutants occur in different situations, e.g. while entrapped in congested area, while driving or sitting in the driven vehicle or residing in the polluted area. Globally 4 billion urban vehicle trips are taken daily and at least 120 millions people spend a considerable time on road side settings. Now in Delhi alone there are 28 lakh vehicles and 20 lakh of these are privately owned. Everyday 10,50,000 Kg of air pollutants are emitted in the capital of India. You can imagine the quantum of pollution by checking the blades of your fan of your house. The problem of this pollution is further aggravated by 16,000 fires on an average in major metros. Above all, traffic mismanagement generate noise pollution and results in accidents. Noise due to traffic has always been an important problem for man. A normal conversation produces 45-60 dBA, passenger car 75dBA and truck 110dBA. A noise more than 45dBA disturbs the normal sleep. Noise of high intensity can cause temporary or permanent damage to hearing organs. Defence and fright reaction resulting from noise can increase blood pressure and level of stress hormones. Chronic and continuous noise pollution causes psychosomatic symptoms, i.e. headache, fatigue and irritability. Poor development of road and inadequate traffic sense and inefficient vehicles increase traffic accidents. In 1995, alone, 222487 people died due to road accidents in India. On an average every 236 minutes, one accident death is reported. Accidental deaths in major cities of India are given below.

With growing urbanization, vehicle density, old outdated vehicles, and population, it has become essential and urgent to reevaluate the present situation of our transport system.

Nitrogen oxide is an irrigating gas and is absorbed into the mucosa of the respiratory tract. It increases incidence and severity of respiratory infections. Asthamatics are more sensitive to the toxic affects of nitrogen oxide. Ozone and other photochemical oxidants affect the waste cleaning ciliated cells and cause nasal congestion or discharge, throat irritation, lower respiratory substernal irritation, cough, sputum production, breathlessness and chest tightness. Asthamatics are more sensitive to ozone as it exacerbate the lung disease by facilitating the entry of allergens. Sulphur dioxide is highly soluble in aqueous surface of respiratory tract and is absorbed in the nose and upper airway where it has irritant effects. High doses or continuous long exposure to sulphur dioxide can cause laryngotracheal and pulmonary oedema. Carbon monoxide is produced whenever there is an incomplete combustion of organic materials. It is colourless, odourless and non-irritable gas. It is rapidly absorbed in lungs and is taken up in the blood where it is bound to haemoglobin, thereby reducing oxygen carrying capacity of blood. Carbon monoxide produces tissue hypoxia by competing with oxygen for binding sites on the oxygen carrying haemoproteins such as haemoglobin, myoglobin cytochrome

Accident Rate in Indian Cities

City	*Total accident death in the year 1995*	*City*	*Total accident death in the year 1995*
Ahmedabad	1341	Lucknow	253
Bangalore	1642	Ludhiana	92
Bhopal	497	Chennai	1154
Mumbai	6295	Madurai	388
Kolkata	771	Nagpur	2508
Chandigarh	259	Patna	354
Coimbatore	372	Pune	1477
Delhi	5547	Pondicherry	511
Hyderabad	1096	Surat	892
Indore	898	Vadodara	588
Jaipur	898	Varanasi	1168
Kanpur	1242	Vishakhapatnam	246
Kochi	289		

oxidase and others. Lungs, brain, heart, and foetus are severely affected by carbon monoxide toxicity. Subjects with previous angina are most sensitive to carbon monoxide. Because of the greater affinity of haemoglobin for carbon monoxide, very low concentration in the atmosphere can lead to very high blood levels. An atmospheric level of carbon monoxide as low as 0.5 per cent, when inhaled can reach a saturation of 75 per cent in 2-15 minutes. Humidity, high environment temperature and physical activity increase the respiratory rate which in turn increase the absorption of carbon monoxide. An idling engine may produce 7 per cent carbon monoxide while the same engine travelling at 96 km/h with efficient tuning may produce less than 0.5 per cent carbon monoxide. Therefore, it is evident that more serious poisoning with carbon monoxide occurs when the vehicle is static and especially within a closed garage, where the level can build up fast. Lead released from combustion of leaded fuels account for 90 per cent of lead in ambient air. Most of the lead in ambient air is in the form of fine particles. Lead gets deposited in teeth and bones. Exposure to high concentration of lead may cause functional disorders of gastrointenstinal tract, e.g. constipation and abdomen pain. It causes anaemia by affecting bone marrow and thereby blood synthesis. Long exposure to lead cause fibrosis in kidney. Fasting, diet with low calcium, vitamin D, iron and zinc have shown to increase lead absorption. On prenatal exposure, lead produces harmful effects on foetus which include reduction in gestational age, birth weight and mental development. Benzene is a known carcinogen. It is a constituent of crude oil which is about 50.16 per cent in petrol. The manor source of benzene is emission from motor vehicles. Polycyclic aromatic hydrocarbons are a group of chemicals formed during the incomplete combustion of wood and fuel. In long-term, these can have mutagenic and carcinogenic effects. Exhaust from diesel contains lower concentration of some gaseous pollutants but higher concentration of particulate bearing organic extracts including aromatic hydrocarbons. Aldehyde levels should not exceed 0.1mg/m^3 as they cause nose, eye irritation, coughing, breathing difficulty and nausea.

The Supreme Court of India took a serious view of the increasing traffic pollution and directed the Government of India to take necessary measures. Some of the steps have been taken while plans are framed for the implementation of others.

- Quality of petrol can be improved by removing lead and diesel by reducing sulphur hydrocarbons (aromatic) content. Reduced aromatic content improves fuel ignition, cold starting and diminishes engine noise. Smoke production can be reduced by adding cetane.
- Fules like natural gas, liquefied petroleum gas and alcohol are relatively cheap, more efficient and cause less pollution. Many developed countries, namely USA, Canada and Netherlands have initiated steps for their use for replacing petrol and / or diesel.

- Well-adjusted engine parts can reduce pollutants by up to 35 per cent. A vehicle emits more pollutants when driven at a slower speed than that under smooth conditions. Hence the steps should be taken for introducing rapid transport system.
- Old vehicles cause more pollution so life span of every class of vehicle should be prescribed and very old vehicle should be scrapped. In addition to this, motor vehicle emission per mile travelled should be monitored.
- Increasing inspection, controlling emission methods mainly for nitrogen oxide, volatile organic compounds, carbon monoxide, and offering incentives to remove older, higher polluting vehicles from road can help in curtailing pollution.
- Traffic pollution can also be regulated by reducing taxes on clean fuels and increasing the licence fee and taxes on older non-conforming vehicles.
- Widening of roads, regular overhauling of vehicles and building separate lanes for different vehicles will help in improving the quality of traffic on roads.
- Planting trees can help in countering the effects of traffic pollution. Neem and Peepal emit large amount of oxygen, so purify the air and help in cleaning the polluted atmosphere. Local Indian plants like *champa*, *chameli* and *mogra* can effectively fight pollution and survive even in severe summer. The plants and trees should be constantly be sprayed with water so that pollutants does not stuck on the leaves and are washed away.
- By limiting the size of the city, adopting. integrated land use and transport planning the trip length of vehicles can be reduced. These steps, if taken effectively will reduce pollution to great extent.
- At present there is no proper planning for cyclists and pedestrians. According to one estimate, 61 per cent of fatal accident victims are pedestrians and cyclists. But by providing separate lanes for cyclists and removing encroachments from sides of roads many fatal accidents can be avoided.
- Appropriate technologies and policies keep on developing. India should adopt those which are currently available. In Hyderabad city scientists at the Indian Institute of Chemical Technology has recently developed a technology to convert carbon dioxide into chemical called 'di-methyl-ether' as a substitute for petrol.
- Running of non-motorized vehicles should be regulated by stringent traffic rules. They increase congestion and hence lead to slow moments of other vehicles.
- By improving existing laws one can restrain offenders and inculcate traffic sense in them. As today law for killing one person or multiple persons due to rash and negligent driving is same and both are booked

under section 304A of Indian Penal Code. Moreover, this crime is bailable offence and justice is usually delivered very late. This develops a sense of apathetic attitude among drivers.

Vehicular Emission load in Major Metropolitan Cities of Indian Estimated Load during 1994
Vehicular Pollution Load (Tonnes Per Day)

City	*Sulphur Dioxide*	*Oxides of Nitrogen*	*Hydro Carbons*	*Carbon Monoxide*	*Total*
Delhi	8.96	126.46	249.57	651.01	1,096.3
Mumbai	4.03	7.082	108.21	469.92	658.6
Bangalore	1.76	26.22	78.51	195.35	304.5
Kolkata	3.65	54.69	43.88	188.24	293.7
Chennai	2.02	28.21	50.46	143.22	226.2
Hyderabad	1.56	16.84	56.33	126.17	202.8
Jaipur	1.25	15.29	20.99	51.28	88.9
Kanpur	1.08	13.37	22.24	48.42	86.2

Exact Division

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A natural number p is said to exactly divide another natural number N, if the quotient N/p is again a natural number (not a fraction). This evidently means that N is not less than p. If k = N/p, then N=pk, so that N is a multiple of p, and p is a factor of N.

Certain elementary tests for exact divisibility have been with us since antiquity, but they are neither exhaustive, nor obvious to a novice learner of the arithmetic of natural numbers. These include the tests for divisibility by 2, 3, 4, 5, 6, 8, 9, 10, 11 and 12. Most persons are unaware that there do exist tests for divisibility by 7, 13, 17 and 19. For that matter, every natural number has a test for divisibility, designed for it. We show, in the sequel, how this can be achieved, but some general considerations for testing for divisibility by a natural number p, relatively prime to 10, will not be out of place here.

If N is the natural number to be tested, then, firstly, any zeroes on the right of N can be ignored. So also can the number p itself, or any known multiples of p. Of course, zeroes on the left of N have no meaning, but p and its known multiples can be ignored from the left as well. To illustrate, suppose N = 42310 and p = 7. We can ignore 0 on the right and 42 on the left, and we are left with 31, which is not divisible by 7. Hence 42310 is also not divisible by 7. Another convenient trick is to group the digits of N into smaller numbers and see if each group is divisible by p. For example, if N = 351428105 and p = 7, we can group N as (35) (14) (28) (105). Since each grouped number is divisible by 7, so is N.

One point of caution may also be stated here. Just because 351428105 is divisible by 7, we cannot conclude that each smaller number is an arbitrary grouping of the digits, such as (351) (428) (10) (5) is also divisible by 7. In other words, the method is only a sufficient condition, and is based on an intelligent grouping of the digits.

Last, but not least in importance, is the good old observation that if a and b are divisible by p, so are a+b and a–b. Thus, for example, 1001 = 980 + 21 is divisible by 7, and 2561 = 2600 – 39 is divisible by 13.

We proceed to describe how a test for divisibility of N by p, (where p is relatively prime to 10) can be designed. Let the number of digits in N be n+1 or more. Then we can write $N = 10^n. a+b$, where b is the integer formed by the first n digits (on the right) of N. For example, if N = 35142 and n = 3, then a = 35 and b = 142. Since p is relatively prime to 10, it is also relatively prime to 10^n. Hence there exist integers x and y such that $10^n . x + py = 1$. These integers x and y are neither unique nor always positive. For example, we have $10.5 + 7.(-7) = 1$ and also $10.(-2) + 7.3 = 1$. We choose the numerically smallest value of x and call it the *multiplicator* for p, of order n. If $N = 10^n . a + b$ is divided by p, we get a quotient q, and a remainder r, where either $r = 0$ or $0 < r \le p-1$. Thus,

$$\begin{aligned} & 10^n.a + b = pq + r \\ \text{i.e.,}\quad & 10^n.ax + bx = pqx + rx \\ \text{i.e.,}\quad & (1 - py)\,a + bx = pqx + rx \\ \text{i.e.,}\quad & a + bx \equiv rx \pmod p \end{aligned}$$

If p is a factor of N, then $r = 0$ and hence p divides $N' = a + bx$. Conversely, if p divides N', we claim that $r = 0$. Suppose not. Then, since p and x are relatively prime, p must divide r, which is not possible, since $r \le p - 1$. Hence $r = 0$, so that p divides N. This means that N and N' are either both divisible by p, or both not divisible by p.

To apply this test, we make sure, first of all, that p is relatively prime to 10. Its multiplicator x is calculated. The order n should be as small as possible. If the corresponding multiplicator x is found to be too large, we increase the value of n, and expect x to decrease numerically.

In practice, the test is applied over and over, until a small number, whose divisibility or otherwise by p is obvious, is left. As an example, let $N = 16132$ and $p = 7$. The *multiplicator* of order one for $p = 7$ is $x = -2$. Hence we multiply the last digit 2 of N by $x = -2$ and add it to 1613 to get $1613 - 4 = 1609$. Again, the last digit 9 is multiplied by -2 and added to 160 to get $160 - 18 = 142$. The next step is $14 - 4 = 10$. This is not divisible by 7. Hence 16132 is also not divisible by 7.

For $p = 3$, the multiplicator of order one is 1, since $10.1 + (-3).3 = 1$. Hence, to test for divisibility of N by 3, we just go on adding the last digit. To illustrate, let $N = 34217658$. Then the procedure gives

$$\begin{array}{r} 34217658 \\ +8 \\ \hline 3421773 \\ +3 \\ \hline 342180 \\ +8 \\ \hline 3429 \\ +9 \\ \hline 351 \\ +1 \\ \hline 36 \\ +6 \\ \hline 9 \end{array}$$

Since 9 is divisible by 3, so is 34217658.

For $p = 7$, as seen earlier, the *multiplicator* of order one is -2. Let $N = 691271$. Then the procedure gives.

$$\begin{array}{r} 691271 \\ -2 \\ \hline 69125 \\ -10 \\ \hline 6902 \\ -4 \\ \hline 686 \\ -12 \\ \hline 56 \end{array}$$

Since 56 is divisible by 7, so is 691271.

For p = 9, the *multiplicator* of order one is 1. Hence, the procedure is identical to the case when p = 3.

For p = 11, the multiplicator of order one is –1. If N = 13459246, the procedure gives

$$\begin{array}{r} 13459246 \\ -6 \\ \hline 1345918 \\ -8 \\ \hline 134583 \\ -3 \\ \hline 13455 \\ -5 \\ \hline 1340 \\ -4 \\ \hline 9 \end{array}$$

Since 9 is not divisible by 11, so is 13459246.

For p = 13, the multiplicator of order one is 4. If N = 12839489, the procedure gives

$$\begin{array}{r} 12839489 \\ +36 \\ \hline 1283984 \\ +16 \\ \hline 128414 \\ +16 \\ \hline 12857 \\ +28 \\ \hline 1313 \\ +12 \\ \hline 143 \\ +12 \\ \hline 26 \end{array}$$

Since 26 is divisible by 13, so is 12839489.

For p = 17, the *multiplicator* of order one is –5. If N = 11198648, the procedure gives

$$\begin{array}{r} 11198648 \\ -40 \\ \hline 1119824 \\ -20 \\ \hline 111962 \\ -10 \\ \hline 11186 \\ -30 \\ \hline 1088 \\ -40 \\ \hline 68 \end{array}$$

Since 68 is divisible by 17, so is 11198648.

For p = 19, the *multiplicator* of order one is 2. If N = 3234567, the procedure gives

$$\begin{array}{r} 3234567 \\ +14 \\ \hline 323470 \\ +14 \\ \hline 3248 \\ +16 \\ \hline 340 \end{array}$$

Since 34 is not divisible by 19, so is 3234567.

For p = 21, the *multiplicator* of order one is –2. Hence the procedure is identical to the case when p = 7.

For p = 23, the *multiplicator* of order two is 3. If N = 12976094, the procedure gives

$$\begin{array}{r} 12976094 \\ +282 \\ \hline 130042 \\ +126 \\ \hline 1426 \\ +78 \\ \hline 92 \end{array}$$

Since 92 is divisible by 23, so is 12976094.

The following observations yield another test for divisibility:

Let $N = a_0 + 10.a_1 + 10^2.a_2 + 10^3.a_3 + \ldots \ldots$ be any natural number, where a_0, a_1, a_2, a_3, ...are the digits from 0 to 9. In the usual notation, we write $N = \ldots \ldots \ldots a_3 a_2 a_1 a_0$. For example, if $N = 431096$, we have $a_0 = 6$, $a_1 = 9$, $a_2 = 0$, $a_3 = 1$, $a_4 = 3$ and $a_5 = 4$. Let this representation of N be divided into k+1 sections, each of length t, starting from the right. Any incomplete section on the left is made complete by appending requisite number of zeros (on the left). The pth section viewed as a separate integer, appears as $a_{tp+t-1}\, a_{tp+t-2} \ldots \ldots \ldots a_{tp+2}\, a_{tp+1}\, a_{tp}$, so that

$$N = \sum_{p=0}^{p=k} \left[10^{tp} \cdot a_{tp} + 10^{tp+1} \cdot a_{tp+1} + \ldots \ldots + 10^{tp+t-1} \cdot a_{tp+t-1}\right]$$

Let r be any integer (positive or negative). If we multiply the pth section by r^p and take the sum over p from $p = 0$ to $p = k$, we get the number

$$N' = \sum_{p=0}^{p=k} r^p \left[a_{tp} + 10 \cdot a_{tp+1} + \ldots \ldots + 10^{t-1} \cdot a_{tp+t-1}\right],$$ so that

$$N - N' = \sum_{p=0}^{p=k} \left[10^{tp} - r^p\right] \cdot \left[a_{tp} + 10 \cdot a_{tp+1} + \ldots \ldots + 10^{t-1} \cdot a_{tp+t-1}\right]$$

We observe that, for all values of p, $10^{tp} - r^p$ has the factor $m = 10^t - r$. Hence, $N - N'$ is divisible by m. This means that N and N′ leave the same remainder, when divided by m, or by any factor of m. Hence, to test n for divisibility by m (or by any of its factors), we form N′ and repeat the process until a small number, whose divisibility or otherwise by m (or by its factors) can be readily seen by mere inspection.

We now present several particular cases:

If $t = 1$ and $r = 1$, then N′ is merely the sum of all digits of N, and $m = 10 - 1 = 9$. Thus, N and N′ leave the same remainder, when divided by 9 or by 3. This is the familiar test (using the digital root) for divisibility by 9 or by 3.

If $t = 1$ and $r = -1$, then N′ is the difference between the two sums of alternate digits of N. Also, $m = 10 + 1 = 11$. Thus, we have the familiar test for divisibility by 11.

If $t = 1$ and $r = 2$, then $m = 8$, and we have a test for divisibility by 2, 4 and 8.

If $t = 1$ and $r = -2$, then $m = 12$, and we have a test for divisibility by 2, 3, 4, 6 and 12.

If $t = 2$ and $r = 1$, then $m = 99$, and we have a test for divisibility by 3, 9, 11, 33 and 99.

If $t = 2$ and $r = -1$, then $m = 101$, and we have a test for divisibility by the prime number 101.

If $t = 2$ and $r = 2$, then $m = 98$, and we have a test for divisibility by 2, 7, 14, 49 and 98.

If $t = 2$ and $r = -2$, then $m = 102$, and we have a test for divisibility by 2, 3, 6, 17, 34, 51 and 102.

If $t = 3$ and $r = 1$, then $m = 999$, and we have a test for divisibility by 3, 9, 27, 37, 111 and 999.

If $t = 3$ and $r = -1$, then $m = 1001$, and we have a test for divisibility by 7, 11, 13, 77, 91, 143 and 1001.

As an illustration, we test $N = 613974$ for divisibility by 167. Now, 167 is a factor of 1002 (= $10^3 - (-2)$. So, we take $t = 3$ and $r = -2$. Then $N' = (-2)1.613 + (-2)0.974 = -252$, which is not divisible by 167. Hence 613974 is also not divisible by 167.

Ancient Sciences

A Selected Comparative Study

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The aim of this paper is to provide with some general information to youth about ancient sciences at an early age which I learnt at a very late stage. The information is generally available in the descriptive form. Some facts of our heritage are scattered. Knowing our ancient is informative, interesting and thought provoking. Reading the 'past', creates the 'present' and builds the future. For me the realization of ignorance was the beginning of this paper. I have tried to present descriptive data in the graphcial form. This, to me, was necessary for the selective comparative study.

The topic of the paper relates to the history of science. I have a background of science and engineering. These disciplines demand discovery fo facts, statement of problem, unbiased and unselfish approaches, undistorted versions of problem, sieving the chef from the grains and drawing of independent conclusions. Equally important, but of national interest, is to generate awareness of science and to inculcate scientific aptitude and enquiry among young generation.

I would suggest that the history of science, history of humanity or any other name that one may give, be made compulsory for students at all stages in schools, colleges and universities at least up to Class XII. The subject taught should be science-oriented. Its content should be factual, interesting, full of diagrams and illustrations. Audio visual aids in the form of a film may be a good approach.

Centres of Learning

The well-known and undisputed ancient centres of learning and the basis of world knowledge are Egypt, Greece, Mesopotamia, China, India, Iran, Bysentine, Romans, Latin came in later. From the eighth century, Baghadad in the East and Cardava in the west, with the satellite towns, became well-known centres of learning and knowledge.

The non-dateable history of science in India is about four to five thousand years old. However, the first dateable record is from the sixth century B.C. and that too in medicine alone. On the contrary the Chinese kept record of their sciences earlier than India.

Two Problems

While compiling an introduction to the history of science, Sarton has pointed out two problems:

1. The problem of language—a common one with all literature. It can be resolved.
2. The difficulty arises when the dates

of the available literature is not known or when it is doubtful. One has to confirm the dates available by foreign sources, i.e. Greek, Latin, Chinese or Arabic. With undateable literature is becomes a problem to ascertain whether Hindu sciences influenced Egyptian, Greek, Chinese, etc. or vice-versa.

Wrong Notion

It appears from the literature that some western scholars have wrong notions about the contribution of Hindu sciences to the world. They were lost in petty chronology. They have underrated at cultural history of India (and China too). I quote Sir James Jeans on this issue:

> "At a times when our own ancestors were thinking of killing animals or one another, perhaps India had a philosophy which was very mature, also art, poetry, literature, and in fact everything which England had not".

In the case of China, Joseph Needham's *The Science and Civilization in China* would fill the gap. He has unfolded the unknown history of Chinese culture and sciences.

Alexandria

After assuming power and incorporating of Egypt into the Roman Empire, Alexander established a library in Alexandria. It was a crucial period in the history of written language and the books. The rulers of Hellenistic empire established libraries in their capital cities. These libraries had works of early and classical literature.

The library at Alexandria had 500,000 books in roll form. At its peak it had one million. The town of Pergamon in Anatolia had a replica of the one in Alexandria on a smaller scale.

The librarians who worked there were distinguished scholars. They used to produce critical appraisals and annotated editions of the Greek literature.

Publishers

Publishing and book selling was in private form to mutually support in copying books. For example, Atticus, the friend of Cicero (106-43 B.C.) originally duplicated the manuscripts of his friend and the famous author. Later on, publishing and selling books established as a regular business. The two outstanding Roman publishers were SDSII publisher to the works of Horrace and Trypho, the publisher of Martial and Quintilin.

It is noteworthy that cultural centres on the same pattern were established in Baghdad by al-Haroun and in Cordova in Spain.*

Use of Technology

With the conquest of Samarkand by Arabs in 704 A.D. manufacture of paper was introduced in the Muslim world. It migrated to Europe via:

1. Baghdad in later than 704 A.D.
2. Egypt in 900 A.D.
3. Morocco in 1100 A.D.
4. Spain 1150 A.D.

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*History of Humanity, Vol. III, p. 84

The manufacture of paper is the significant turning point in the history of learning and knowledge. The process of learning and acquisition of knowledge was accelerated. Books began to reach at the door-step of the common person. Besides this, irrigation, textile industry, carpet industry, wood craft, copper craft, fine arts, ceramic industries were established for civilized living.

Law and order, security and safety, propserity and dignity, tolerance and goowill seem to have upper hand in every society during the period.

Case Study

Based on Sarton' *An Introduction to the History of Science*, I have tried to make a limited comparative study of the achievements of a few pioneering countries. The countries chosen for study are India, China, Greek Byzentine, Hellenstic, Roman, and Arabs.

Sarton has divided each century into two parts of 50 years each. I have adopted the same in graphical representation. The period under study covers from 7 B.C. to 13 A.D. Science activities have been coded for the sake of convenience of plotting the graph. A list of coding is given Table 2.

The study is divided into two parts:

1. Comparative study — graphical representation
2. Case study of India, China, and Arabs giving salient feature of the scientific cultural advancements of the countries under study.

Comparative Study

Using the contents given at the beginning of the Sarton's *An Introduction to the History of Science*, graphs were plotted. Figure 1 is such one graph. Similar graphs were plotted for:

1. India, China and Greeks
2. India China, Hellenstie and Romans
3. India, China and Byzentine
4. India, China and Arabs.

The findings of the graphs are given in Table 1. While plotting the graphs, related science activities were grouped together to accommodate as many activities as possible in the limited space available on the graphs.

Science Clock

George Sarton in *An Introduction to the History of Science* has divided the entire history, beginning from the time of Plato (fourth century B.C.) into period of 50 years each. The duration of Plato, Aristotle and Archamedes is 50 years each, that of China 100 years, and that of Arabs sciences of 300 years. The graphical presenation of the science clock is given in Fig. 2.

TABLE 1
Comparative Statement of Emerging Sciences

S. No.	Country	EMERGING SCIENCES A - 1st to 6th B.C.	B-1st to 7th A.D.	C-7th to 12th A.D.
1.	India	Philology; Astronomy and Astrology?	Astronomy, Mathematics and Medicine	Astronomy, Maths, Medicine, Philology and Others
2.	China	Medine, Philosophy, Philology, and/or Others	Astronomy, Geography, Mathematics, Medicine and Philosophy	Astronomy, Botany, Geography, Maths, Medicine. Physics and Others
3.	Greeks	Astronomy, Mathematics, Medicine, Philosophy, Philology and/or Others		
4.	(a) Hellenstic (Alexander) period		Astronomy, Natural History, Geography, Maths, Medicine, and Philosophy	
5.	(b) Romans period		Astronomy, Natural History, Maths and Medicine	
6.	(c) Byzentine period			Medicine, Physics
7.	Arabs			Astronomy, Botany, Geography, Law, Historiography, Maths, Medicine, Philosophy, Philology, Physics/Alchemy

TABLE 2

Coding of the Science Activities

Code Number	*Science Activity*
1.	Astronomy
2.	Astrology
3.	Botany, Biology, Natural History
4.	Geography, Geology, Minerology
5.	Law
6.	Historiography
7.	Mathematics
8.	Medicines
9.	Philosophy
10.	Philology, Language, Loxicology
11.	Physics / Alchemy
12.	Sociology, Education
13.	Technology, Technicians

Note: Code numbers used in the graphic representation refer to the science activity.

Lower and upper portion of each block represents first and second half of each century respectively.

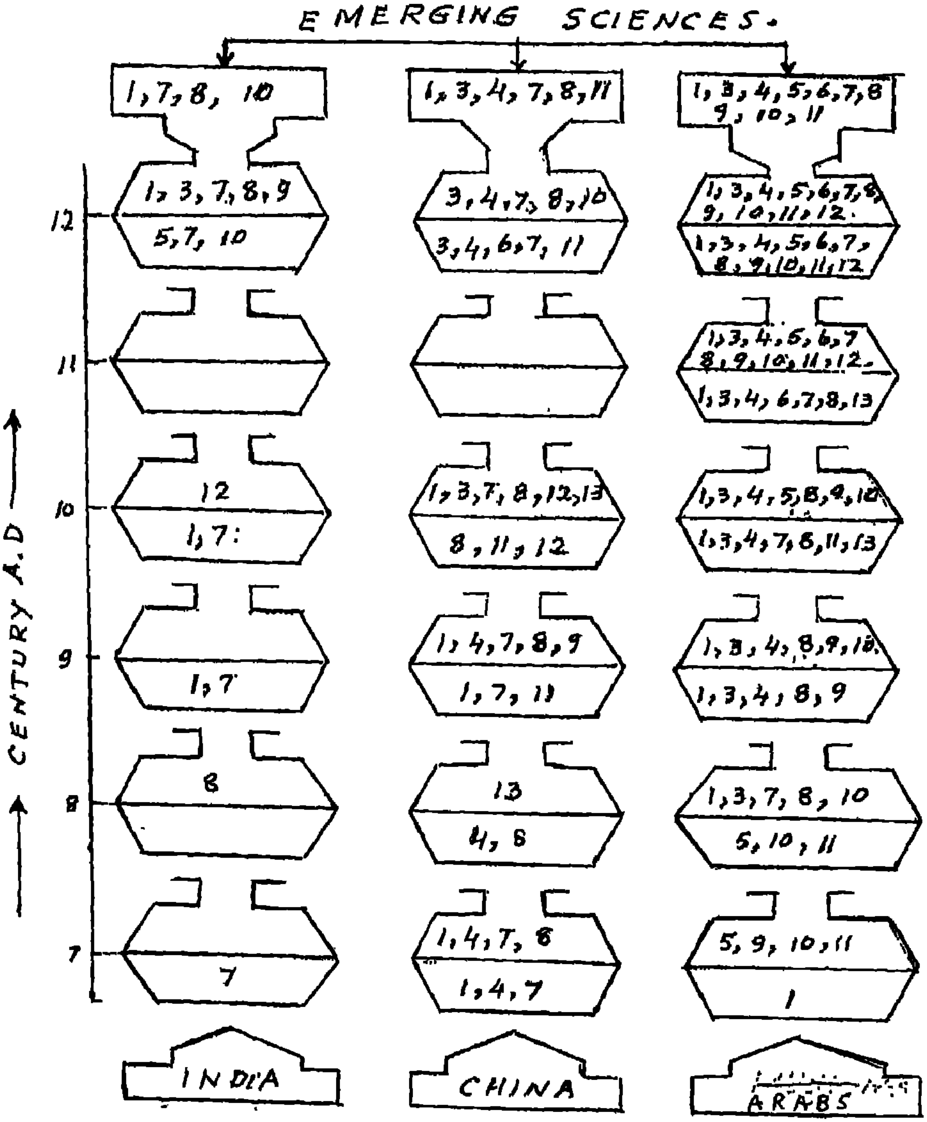

Fig. 1: *Emerging Sciences. 7th to 12th Century* A.D.

Explanatory notes to Figure 1:

(i) Each Kalsa (sacred water pot) is divided into 50 years each. Thus, One Kalsa represents one century. The numbers within the Kalsa, i.e. 1, 2, 3, 4 .... represents the science activity of the century.

(ii) Similar graphs were drawn for India, China, Greeks Hellenstic, Roman and Byzentine periods. The comparative statement of the emerging sciences, based on the graphs, are consolidated in Table 1 after decoding.

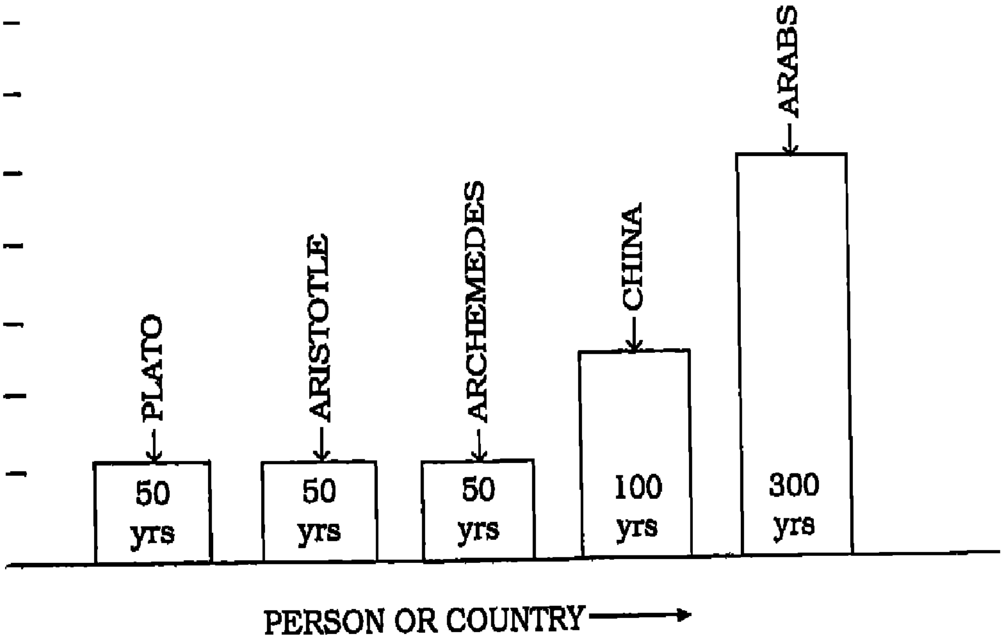

Fig. 2: *Science Clock*

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angle ABC is

quadilateral QJBS. Thus, the quadilateral QJBS is a rectangle. Therefore, both the diagnols QB and JS will bisect each other at the point O.

$\therefore OB = OS = OJ = OQ = \frac{r}{2}$

Now suppose given $\angle ABC = 3\alpha$, $\angle OBT = \beta$ and radius $PB = QB = r$

Now $\because$ BG is the bisector of $\angle ABC$

$\therefore \angle ABE = \angle CBE = \frac{3\alpha}{2}$

Now $\because OB = OS = OJ = OQ = \frac{r}{2}$ and BS // JQ.

$\therefore \angle OBT = \angle OST = \angle OQJ = \angle OJQ = \beta$

After this the point J and D are also connected.

Now $\therefore \angle OJB = 90 - \beta$ ($\because \angle QJB = 90^\circ$ and $\angle OJB = \beta$)

and $\angle BJD = \angle BJF + \angle FJD$

$= 90^\circ + \beta$ ($\therefore \angle BJF = 90^\circ$ and $\angle FJD = \angle OJQ = \beta$)

$\therefore \angle OJB + \angle BJD = 90 - \beta + 90 + \beta$ 180°.

Therefore DS is a straight line.

Now $\because$ DL // QJ

$\therefore \angle MDS = \angle QJS = \beta$ (corresponding angles).

And $\angle BOD = \angle OBT + \angle OST = \beta + \beta = 2\beta$.

(Because $\angle BOD$ is an external angle)

Now $\because$ BG is the bisector of $\angle ABC$ and $\angle ABC = 3\alpha$

$\therefore \angle ABG = \angle MBG = \frac{3\alpha}{2}$

But DL // BG

$\therefore \angle BMD = \angle MBG = \frac{3\alpha}{2}$ (alternate angles)

And also $\angle MDB = \angle GBC = \frac{3\alpha}{2}$ (corresponding angles)

$\therefore \angle MDB = \angle BMD = \frac{3\alpha}{2}$

Now in the Δ PBT, point U is the mid point of PT because UL is the perpendicular bisector of PT. In this triangle UM // BT. Therefore M is also the mid point of PB.

$\therefore BM = \frac{PB}{2}$ and so that $BD = BM = \frac{r}{2}$

Now in the ΔODB

$OB = BD = BM = \frac{r}{2}$ and $\angle BOD = 2\beta$

$\therefore \angle BOD = \angle ODB = 2\beta$

Now $\angle MDB = \angle MDS + \angle ODB = \beta + 2\beta = 3\beta$

But $\angle MDB = \frac{3\alpha}{2}$

$\therefore \frac{3\alpha}{2} = 3\beta$ Sθ $\beta = \frac{\alpha}{2}$

Now $\angle PBQ = \angle PBG - \angle OBS = \frac{3\alpha}{2} - \beta = \frac{3\alpha}{2} - \frac{\alpha}{2} = \alpha$

and $\angle QBR = \angle QBS + \angle RBS = \beta + \beta = 2\beta = \alpha$

($\because$ In the ΔQBS, and ΔRBS, $QB = RB = \gamma$ and $QS = RS$ (from construction) and side BS is common.

$\therefore \Delta QBS \cong \Delta RBS$, therefore $\angle QBS = \angle RBS = \beta$)

And also $\angle RBY = \angle GBY - \angle RBS = \frac{3\alpha}{2} - \beta = \frac{3\alpha}{2} = \frac{\alpha}{2} = \alpha$

Thus $\angle PBQ = \angle QBR = \angle RBY = 2$ and Chord $PQ = QR = RY$

Note: 1. If the given $\angle ABC$ is greater than 180° or in the above figure ∠ABC is a reflex angle. Then the reflex angle ∠ABC = 360° – 3α.

$$\therefore \frac{\text{Reflex } \angle ABC}{3} = \frac{360 - 3\alpha}{3} = (120° - \alpha)$$

Now for dividing the reflex ∠ABC, the circle is completed with the same radius PB and point B as centre in the same figure. After this making an angle 120° with the line BR a line is drawn. Now this line meets at the point Q′ to the major segment PY. Now subtracting the angle α or ∠RBY from 120° the chord YQ′ is drawn. Now chord YQ′ will divide the reflex angle ∠ABC or major segment PY into three equal parts.

In other words YQ′ = RQ′ = PR′, Thus ∠YBQ′ = ∠Q′BR = ∠PBR′.

2. By division any angle into three equal parts we can easily draw the angles of 5°, 10°, 20°, 25°, 40°, 80°, etc. with the help of scale and compass.

For Meaningful Learning of Science and Mathematics Encourage Students to Ask Questions

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Children are naturally very inquisitive and acquire all their early knowledge by asking all sorts of questions about their environment. As they grow up, they continue to ask questions, but sometimes these questions are inconvenient for the parents or the teachers who are not in a position to answer these questions. Honestly they should say that they do not know the answers to these questions or they should use these questions to lead the children to more proper questions and answer them. However, they usually say "Good children do not ask such questions". As the children grow older and join school, the answer given is "This is not in your course and no such question will be asked in the board examinations. As such do not waste your time on such questions". It is presumed that the only object of learning mathematics is to pass board examination in mathematics with good marks and whatever is not relevant to board examinations in mathematics is not relevant to learning.

The result is that after some time, students stop asking questions, because they are brainwashed into believing that passing board examination is the only goal of learning mathematics and science. Their curiosity is completely killed and learning of mathematics and science suffers terribly. Curiosity is a great motivation for learning and if this curiosity is killed, no real learning can take place.

We always ask the students to be curious, but in practice we snub them, when they put searching questions. This is done sometimes to hide the ignorance of the teacher and sometimes by a genuine feeling that class time is too precious to be wasted on answering questions not relevant to the present type of examinations. Honestly the teacher should tell the student "I do not know the answer, but I will try to find out and let you know"or "The answer is available in such and such book" and a complete reference to the place in the book where the answer is given may be provided to the student. In any case the answer of the teacher should be perfectly honest and should try to encourage students to ask more questions since students learn more by the answers to those questions that arise in his mind rather than by the answers to the questions that the teacher raises himself.

Good teaching should deliberately develop the natural curiosity of the students and encourage them to ask more and more questions. The students should also be trained to discuss these questions among themselves and ask the teacher only those questions to which they cannot find answers by such mutual discussions. They should be trained in asking and posing questions.

I have given lectures to students, at all levels, both in India and ten other countries. I invite questions at the end of each lecture and my experience is that the children in developed countries in general, ask many more questions and more meaningful questions than students in India. One possible reason is that there all the students are encouraged to ask questions, while here they are discouraged from asking questions.

Thus, I gave a lecture to students of Class VI in Australia on the subject of 'the Applications of Mathematics' and when I invited questions, 40 students of the class raised both their hands. When I asked why they were raising both their hands, they said, "Sir each one of us has more than two questions to ask, but none of us has more than two hands". They asked questions like "How is mathemsltics useful in constructing buildings, bridges, dams, aeroplanes, ships, etc.? How is it useful in making guns, rockets and missiles? How is it useful in sending man to Moon? Can it help us in finding whether there is life on Mars? Can it prove that God exists? Can it help in growing more wheat or improving industrial production?" I took about two hours to explain the applications of mathematics in more than 100 fields and our discussions terminated only because after two hours, the school buses were ready to take children to their homes.

Again when I made a statement in one of my lecture that "Every result in mathematics is beautiful and is a miracle of the human mind", the students immediately stopped me and asked "How are theorems in geometry or formulae in algebra or trigonometry beautiful and how they are miracles?" And they asked me to answer this question for each of the theorems or formulae they had studied.

Since they had asked the questions, they were all in full attention when I replied to these questions and a great deal of learning took place in these discussions. I myself enjoyod the process and had to do hard thinking to reply to their questions.

I recall another instance when I was a young lecturer in Delhi University. Many distinguished mathematicians used to come from other countries to give lectures on their research topics, to the teachers of the university and at the end, they invited questions, but usually no questions were asked. The Head of the Department called me one day and said "Dr Kapur, it is very embarrassing to me that nobody asks questions. These visiting professors take a very bad impression of Delhi University with them. You are the most brilliant teacher I have. Why don't you ask questions at the end of these lectures?" I told him "Sir, these persons are talking of research in 20th century mathematics, but what we learnt and what we are teaching is 18th or 19th century mathematics. We do not understand most of what they are saying and we do not want to make a fool of ourselves by asking questions which show our ignorance". The Head of the Department still insisted that I should ask some questions. I then developed a strategy of asking the following types of questions. "You have talked to us about some of the research problems you are working on. Can you tell us about some open unsolved problems in this area? Can you tell us about some other persons who are doing research in this area? What other areas of research are being pursued in your university? Can you give us more references, so that those of us who want to do research in this area can start with them?" The distinguished speakers were very happy to reply to these questions and very often we learnt much more from their replies to these and other similar questions than we learnt from their original lectures. The distinguished speakers were happy because some meahingful questions were asked from them, the Head of the Department was happy and I was happy because I had got some useful information from their answers to my questions. Though I started this practice at the request of my Head of the Department, I found it very useful in learning about developments in modern mathematics.

The point I am making is that whenever one listens to a lecture, he should be very attentive and right from the start, think of the possible questions that he may like to ask at the end of the lecture. If one understands the lecture one will be able to ask good questions, but even if one does not fully understand the lecture, one would be in a position to ask some questions about some part of the lecture which one may have understood. Even otherwise one's desire to ask questions will lead to one's better understanding of the lecture. Similarly, when one reads an expository article or a research paper, one should ask oneself at the end, questions like the following "What was the author trying to convey? Do I agree with all his views or I not agree with some of his views and if so, why? He has proved some theorems under certain conditions. Are all the conditions necessary or are they all sufficient or are the both necessary and sufficient? Can I find an alternative proof? Can I modify some of the conditions and prove some new results? Can I use this technique to solve some other problems?" and so on.

Every problem in mathematics or science which is solved, in general, gives rise to new problems to be solved and new questions to be answered. A good student or a good researcher is one, who can identify these problems or those questions and then proceed to solve them. However, only those who have been systematically trained in posing problems or those who have learnt the art of posing problems by hard thinking can succeed and then they become good students and good researchers.

In science we have quizzes and question-answer sessions on TV. In mathematics also we should encourage quiz contests and problem-solving and problem-posing sessions.

When a student studies an algorithm for finding square root, he should ask whether similar algorithms can be developed for finding cube roots or fifth roots. When he solves quadratic equations, he should ask whether he can solve equations of third and fourth degrees. When he solves trigonometric equations, he should ask whether he can solve equation involving logarithmic and exponential functions. For every topic that he learns, he should ask for the applications of that topic, because most topics in school mathematics were developed to solve some practical problems and later on these topics helped in solving many more practical problems. He should ask why the topic was created in the first instance and how and why it was developed later and what are the interactions of this topics with other topics in mathematics. The students can ask such questions for arithmetic, algebra, geometry, trigonometry, calculus, etc. They should be convinced about the beauty and utility of every topic they study.

Mathematics and science are growing exponentially and becoming double in a period of ten years or less. This is because of the tremendous curiosity of the scientists and the mathematicians and this curiosity has to be nurtured and developed in the school students in a big way. Students should be rewarded not only for solving problems given in the textbooks, they should also be rewarded for posing good intelligent questions, because the understanding of a topic can be measured by the type of questions asked by the students about it. Just as we have Olympiads in science and mathematics, where students ability to solve problems is measured, we should also have science and mathematics Olympiads in which students' ability to ask deep and meaningful questions can be measured.

If a student has learnt about all the results in mathematics and science, but has not learnt the art and science of posing good problems, he cannot become a scientist or a mathematician or be in a position to apply mathematics and science, for developing new ideas and products. As such, we should encourage and train all our students and teachers in asking questions, posing problems and being infinitely curious and inquisitive about phenomena in Nature and Mathematics. Our science and mathematics education will improve tremendously if we develop this habit of asking questions and posing problems by our students. The thinking power and knowledge of our teachers will also improve tremendously if they decide to give honest answers to the questions raised by their students or by their colleagues. This will create an academic climate conducive to excellence in mathematics and science education.

Azolla — An Eco-friendly Fertilizer for Fresh Water Aquaculture

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Fertilizers are very important for providing mineral nutrition to plants. The widely used fertilizers are chemical fertilizers. However, they not only pose such hazards as contamination of water by nitrates and increased salination in the soil but are also very expensive from the energy point of view. The focus obviously has, therefore, now shifted to biofertilizers.

A nitrogenous biofertilizer that finds extensive use in fresh water aquaculture is Azolla. It is a free-floating aquatic fern having remarkable potential for fixing atmospheric nitrogen. It has, therefore, been utilized since many hundreds of years for fertilizing ricefields. Azolla lives in association (in symbiosis) with a cyanobacterium, *Anabaena azollae* which is capable of converting the gaseous nitrogen in air into nitrogen which can be directly utilized by the plant for its growth. Cyanobacteria, also known as the green algae, are related to bacteria in their structure and to plants in their photosynthesis ability. *Anabaena azollae* is located in a cavity of the leaves of Azolla.

Though Azolla can also directly absorb small quantities of nitrogen from its surroundings, the micro-organism Anabaena meets its major nitrogen requirements. In return, Azolla supplies some carbonaceous elements (which are products of photosynthesis) to the micro-organism.

The utilization of Azolla as a green fertilizer has a long history. About 900 years ago some Chinese and Vietnamese peasants is discovered that an aquatic fern, Azolla, could become a priceless green manure for the cultivation of rice. However, at the beginning of this century only the farmers of three villages in the province of That Binh, 100 km from Hanoi, seemed to know the secrets of Azolla. It was only in 1954 that this secret was made public, enabling a rapid extension of the use of this fern. In the provinces of the south-east of China, Azolla is now one of the most important green fertilizers for the cultivation of rice. Besides, Vietnam and China Azolla has also been used as a biofertilizer for rice in all major rice-growing countries of the world including India, Thailand, Korea, Philippines, Brazil and West Africa.

At present, seven species of the Azolla fern have been identified in the world. One of them is *Azolla pinnata* of Senegalese origin. Another heat-tolerant type of species is *Azolla microphylla*. This Latin-American species was introduced in India a few decades ago. A temperate species of European origin is *Azolla filiculoides*. A couple of hybrids obtained from the crosses between different species of Azolla are also available in the world now. One such hybrid is obtained by crossing Azolla microphylla with

Azolla filiculoides. Several of these hybrids have high nutritional value and grow fast. The hybrids with as high as 50 per cent nitrogen (4 to 4.5 per cent nitrogen on a dry weight basis) can stand both heat and cold well.

Azolla mutants with a high degree of tolerance to salinity have been developed at the International Atomic Energy Agency (IAEA), Vienna and scientists in China and the US are now working on introducing a Bacillus thuringiensis (Bt) toxin in Azolla to fight insect pests.

The Azolla fern is mainly propagated by vegetative means. However, recently some techniques for multiplying it through sporocap technology have been developed in many research institutions in the world.

Azolla can thrive well under diverse agro-climate conditions. It can survive in acidic as well as alkaline water bodies and can stand salinity well. However, it prefers a placid water surface with a pH of 4-7, temperature between 20–30°C and 20-50 per cent of exposure to sunlight. Under optimal conditions of growth doubling of Azolla takes place in three days. It has the property of decomposing rapidly. After about four weeks of its burial in the ricefields, the nitrogen accumulated in the plant is released into the soil. Each crop of Azolla per hectare can, on an average, fix about 40-60 kg nitrogen.

Other Uses

Besides fertilizing rice fields Azolla is also used as feed for fish, ducks, poultry and cattle. It is also used as forage for green carp. Azolla provides an eco-friendly approach to fresh water fish farming. It is used as a suitable substance for enriching the fish ponds. In China, Azolla is used extensively in the rice-fish composite systems. Fish feed voraciously on the floating fern, and their excreta goes to fertilize the rice. In this manner the productivity of both fish and rice can go up significantly in the farming system. Using such system, the Chinese farmers have harvested between 1.5 and 4 tonnes of fish in addition 10 tonnes of rice per hectare in two seasons.

Azolla fern is rich in protein and fats. On a dry weight basis it contains 13 to 30 per cent of crude protein in addition to about 4.4 to 6.3 per cent crude fat. It is also rich in vitamins, minerals and carotene. It has been found that ducks and hen fed with Azolla lay eggs with yolk of deep yellow pigmentation. Farmers of the Phillipines feed Azolla to snails which are then fed to ducks. One of these farmers, who had integrated Azolla with fish, snail, ducks and pigs in his 0.6 hectare farm, netted ten times gross profit than the neighbouring farmers having the same size holding.

As a nutrient-rich biomass, Azolla is also fed into biogas plants and the digested slurry is used for manuring rice fields, vermipits and fish ponds.

Use of Azolla has another beneficial effect in that it successfully controls aquatic weeds which would otherwise compete with the crop for nutrients. Azolla also possesses the potential of scavenging nutrients from the enriched water. Each crop of Azolla per hectare can scavenge 10-15 kg phosphorous, 30-

40 Kg potassium and other nutrients like calcium, magnesium, zinc, iron, etc. Azolla has also been found to improve the physical, chemical and biological characteristics of the soil. Culture of Azolla in hyperentropic waterbodies has been found to improve water quality.

The multipurpose Azolla thus helps pave way for an economic and eco-friendly nutrition management in fresh water aquaculture. The progress of plant molecular biology has opened up new vistas for the study of the Azolla fern. The objectives are the creation, by genetic manipulation, of ferns that are resistant to fungus and insects and to low temperatures so as to be able to extend the cultivation to less tropical regions.

Implications of Research for Classroom Teaching

For Better Understanding of Science

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Teaching of science in the classroom involves many aspects such as teaching of concepts, teaching problem-solving, developing experimental skills, etc. In this article we restrict ourselves to its two aspects only namely; teaching of scientific concepts and the development of the ability to solve problems. It is attempted to review the research done in these two areas with their implications for classroom teaching. Of course, no claim is made of being exhaustive; it is selective and indicates the general trends as viewed by the author.

To understand science essentially includes understanding of scientific concepts and having ability to solve problems related to them. The two are not identical. If one understands concept, it is not necessary that he/she would be able to solve the problem based on that concept. Though the reverse is more likely to be true. Ability to solve problem requires understanding of concepts to a larger extent. Heuvelen (1991 A) has shown that the development of problem-solving ability enriches understanding of the concepts.

Teaching of concepts

Alternative Frameworks: The Stumbling Blocks to Learning

Teaching of science is a major component of school level curriculum. However, the classroom experience shows that a large fraction of students face considerable difficulty to learn meaningfully the scientific concepts (e.g. Halloun and Hestenes, 1985; McDermott and Shaffer, 1992; Goldberg & McDermott, 1987; Saxena, 1990, 1991; Watts & Gilbert, 1983). This is reflected in poor ability to apply the concepts to explain an observation, to make predictions (for review, see e.g ASPEN-APPTEA, 1991; Driver et al., 1985; McDermott, 1984; Novak, 1987; Osborne & Wittrock, 1983; Saxena, 1994) and to solve problems (Ausdal, 1988; Gil Perez et al., 1990; Gil & Martinez-Torregrosa, 1983; Mettes et al., 1980; Gilbert, 1980). This happens despite number of years of education in school and college/university.

There are many factors responsible for this. One important factor that has been identified is the existence of alternative frameworks (Driver, 1981) among students. Generally, during teaching transmission model (Mestre, 1991) is used implicitly. It assumes that the children come to the classroom with a blank mind-slate and any message could be inscribed on it without distortions. Contrary to this assumption, it has been found that the children come with their own ideas that are many times at variance with scientific ideas. These ideas have been called by different names such as alternative framework (Driver, 1981), misconception (Helm, 1980), preconception (McDermott, 1984), alternative conception (Driver & Easley, 1978) and children' s science (Gilbert , Osborne & Fensham, 1982). Sometimes these are categorized as spontaneous and alternative conceptions (Metioui et al, 1996). The ideas that the children develop prior to instructions are called spontaneous conceptions whereas the alternative conceptions also include alternative ideas that are developed during the period of formal instructions. However, all ideas are not equally deep-rooted in the mind of the learners, Students are reluctant to change some ideas; these are hard core ideas. Whereas there are other ideas that the students might change easily when confronted with contradictory evidence; these are protective belt of ideas (Linn, 1986).

Sometimes children's naive ideas are considered to consist of a collection of a coherent and systematic set of ideas and are called mini theories. Another viewpoint is that they are not systematic enough to be called a theory and are just collection of fragmented ideas. They consist of certain phenomenological principles which are simple abstraction of everyday experiences (Vasniadou & Brewer, 1992). Vosniadou and Ioannides (1998) make a distinction between naive framework theory and specific theory. The former is built in early infancy and consists of fundamental ontological (related to kind of entities we assume to exist and the way they are categorized) and epistemological (about the nature of knowledge) presuppositions. The specific theories contain a set of beliefs or presuppositons that describe the characteristics of physical objects. Accordingly, misconceptions are considered as learner's attempt to interpret a phenomenon within the existing specific theory that is contradictory to scientific view. It has been shown that sometimes they resemble with classical pre-Newtonian ideas and are difficult to change (Clement, 1982; Hashweh, 1988; Gil Perez & Carrascosa Alis, 1994).

Many studies (e.g. Halloun and Hestenes, 1985; McDermott, 1984, Clement 1982, McCloskey 1983, Minstrell 1982) have shown that the students alternative frameworks are highly stable and there is not much change in them as a result of classroom teaching over number of years. This itself is an evidence that some of the alternative frameworks are deep-rooted. There are variety of reasons for the stability of alternative frameworks ranging from their roots being in the cognitive ecology of the learner, lack of teacher's knowledge about student's ideas, no serious attempt by the teacher to remove them and unsuitability of the strategy adopted by the teacher to remove them.

Origin of Alternative Frameworks

Many studies have been conducted to find out the origin of alternative frameworks. It is generally agreed that there is no single cause/process responsible for their origin. Many processes are at play simultaneously out of which the more common processes are the following:

1. *Kinaesthetic of sense experiences*: Some experiences make their impression on the human being much before they are able to formalize them. The common misconception that it requires a force to move an object with constant velocity comes in this category of alternative frameworks. Due to partially correct observations sometimes children tend to interpret the experience in a biased manner.
2. *Metaphorical use of language in everyday life:* Solomon (1983) is of the view that exposure to non-scientific explanation through mass media and other means could be one source of generation of alternative frameworks. The inability of the learner to distinguish between scientific world of the laboratory and classroom and the life world of outside environment; and to switch over from one 'world' to another is the reason of learner's many problems. Force, work animal are some such words that have different meanings in classroom world and outside world.
3. *Linguistic interference* : Apart from different meanings of a word in everyday life and scientific literature, certain phrases specific to a language, particularly related to the first language may also generate some misconception. *Ankhon Ki jyoti* for example, in Hindi is one such phrase which may give the impression to the child that there is light being emitted by the eye.
4. *Lack of understanding of scientific concepts:* It appears that a large number of concepts or ideas are not assimilated well and are, therefore, not connected to the proper schema. 'Acceleration is zero when velocity is zero' is one such example. It occurs because of lack of understanding of the concept of acceleration. Some misconceptions that could result due to lack of understanding are:

   The displacement is the total distance covered.

   The resistors connected in parallel are diagramatically parallel.

   Graphical representation of transverse wave and its motion.

Reif and Allen (1992) have argued that (i) disconnected knowledge elements, (ii) deficient applicability conditions or lack of discrimination, and (iii) lack of procedural knowledge could be responsible for wrong interpretations of events by the students.

The experiences in different situations lead to the development of mental models (Redish, 1994; Vosnaidou, 1994). They are generated to deal with different situations on the spot. The mental models are used frequently, are stored as a single structure in long-term memory and are retrieved when needed. They consist of closely linked data with some processes and rules for use. The properties of mental models (Redish 1994) are:

1. They consist of propositions, images, rules of procedures and statements as to when and how they are to be used.
2. They may contain contradictory elements.
3. They may be incomplete.
4. People may not know how to 'run' the procedures present in their mental models.
5. Elements of a mental model do not have firm boundaries. Similar elements may get confused.
6. Mental models tend to minimize expenditure of mental energy. People will do extra physical activities, sometiems very time-consuming and difficult – in order, to avoid a little bit of serious thinking.

The conceptual change is obtained through modification in one's mental models which could be due to gathering of additional information or changes in individual's ideas, beliefs or naive theories.

The models play an important role when attempt is made to learn new ideas. It is easy to learn those ideas that are related to what is already learnt. The relationship could be in terms of analogy, extension of concept or example. If new information is contradictory to the existing mental model it requires radical change and is difficult to obtain. Failure to learn scientific ideas frequently occurs due to this and classroom teaching does not seem to make the expected behavioural changes in students and the number of years of science teaching, sometimes does not exhibit any real impact. During teaching the following three aspects are important to be considered (Osborne & Wittrock, 1983):

1. Children have meanings for words and views about how and why things in their natural environment behaves as they do from a young age.
2. The views and meanings held by children are sometimes uninfluenced by considerable exposure to science teaching.
3. When children's views change as a result of new learning experiences they sometimes change in ways unanticipated by teachers or curriculum designers.

Characteristics of Student's Ideas

The student's naive ideas about scientific concepts have some typical characteristics which distinguish them from scientists concepts. These can be described in brief as the following (Driver, 1985; Driver, Guesne & Tiberghien, 1985; Osborne & Freyberg, 1985):

1. *The ideas are sometimes developed prior to teaching:* From a young age, prior to classroom teaching, the process of generating ideas about various

phenomena commences, children make their own theories, have their own ideas about various phenomena they encounter such as light, heat, plant, life, death, force, motion, etc. When they come to the classroom and are exposed to scientific idea that is at variance from their previously held idea, they either (i) modify the previous viewpoint, (ii) possess two ideas simultaneously, one for the classroom and the other for personal interpretation and understanding, and (iii) discard the original idea and adopt the scientific explanation.

2. *The ideas are stable:* Children's ideas are generally strongly held and do not change easily. Due to experience and repeated use of preconceptions these are automatically and unconsciously evoked once certain conditions are satisfied (Hashweh, 1986) and are not modified or replaced as a result of traditional classroom teaching. Sometimes they seem to change, but students retrograde to the previously held ideas when they encounter a new situation that they find difficult to explain. To modify or replace them by scientific ideas special efforts are to be made by the teacher.
3. *The ideas are content-specific:* The explanation/ideas offered by the child in a situation may not be applied to another scientifically similar situation. Thus, they lack generality and have limited application. For 'different' situation a child may have different theory. Moreover, same person may provide different ideas about a situation on different occasion also.
4. *Children's thinking is dominated by observable features:* The explanation offered by the child is dominated by observable features of the event such as applied force and ignores unobservables such as friction, For this reason sometimes children argue that light exist at only those places where it falls on different objects but not in the medium.
5. *There are some common ideas:* Similar ideas are found among students coming from different countries, cultures and age. This remarkable similarity leads us to think the origin of such ideas is related to similar sense experiences.
6. There is similarity in the evolution of scientific ideas and development of children's intuitive conceptions. This resemblance in children's ideas and medieval scientific ideas, though limited cannot be ignored (Git-Perez & Carrascosa-Alis, 1994; McCloskey, 1983).
7. Children use imprecise language and undifferentiated terms to explain their ideas. Due to this they may explain similar phenomena using different arguments.

Some typical children's ideas are given seperately in Appendix I.

Failure of transmission model to deliver the goods in science teaching led to the development of and experiment with different approaches. Discovery approach based on positivist view of learning is one such important attempt in this direction. It assumes that it is possible to study an object or phenomenon objectively and arrive at the universal truth unaffected by the previous ideas or beliefs. Through logic, mathematical applications and objective interpretation of experience one could discover the reality. Many curricula, such as PSSC, Nuffield and HPP based on this philosophy were developed and tried out. These attempts failed in two of their objectives namely, conceptual learning and understanding the nature of science. In this context Driver (1983) draws attention to the inherent contradiction underlying in the approach. She states:

> '... pupils are quick to recognize the rules of the game, when they ask, Is this what was to happen? Or, Have I got the right answer?' and
>
> '...The intellectual dishonesty of the approach derives from expecting two outcomes from pupils laboratory activities which are possibly incompatible. On the one hand, pupils expected to explore a phenomenon for themselves, collect data and make inferences based on it; on the other hand, the process is intended to lead to the currently accepted scientific law or principle'.

What Driver is pointing out is the fact that teaching based on predecided objectives and making of its discovery by learners independently are incompatible propositions. Many authors have pointed out that the complete autonomy to the pupil in conduction of the activity and the lack of attention to conduct and the extreme induction in which this model fell into as the main causes of its failure (Gil-Perez and Carrascosa Alis, 1994).

Constructivist Approach

During the last couple of decades constructivism has emerged as a powerful way for teaching science. It assumes that the knowledge is constructed through experience, is continuously refined in view of new observations and does not exist independent of human experience. Brain is an active agent which continually draws inferences on the basis of information received by it. The brain is assumed to be selective in receiving information while it ignores other information which it considers as useless for its purpose. The mental constructs are mental models which are continually tested against the new experiences and are modified/rejected if need be. The prior experiences, beliefs and emotions affect the individual's perceptions and interpretation of events. In this way, the constructivist view of concept development differs from classical view which considers that all instances of a concept have some common properties. It is 'either-or-kind' of situation which makes it difficult to see the concept development in terms of single bound entities acquired through 'all-or-none' step. The 'actional' view of concept is active, constructive and intentional. Sometimes it is compared with flame which is often stable, yet continuously dynamic. In the context of constructivist approach, student's errors are recognized as part of developmental phenomenon and not due to misunderstanding of the concept: cognitive deficiency, inadequate learning, carelessness on the part of the learner and poor teaching.

The process of concept development takes place as a result of assimilation and accommodation. The new experience is understood in the context of existing schema. As a result, the existing schema are modified and the development of new schema takes place. This could lead to the development of proper, conception or misconception. The same process is responsible for the development of scientifically acceptable conception and for misconception. In constructivist view all individuals construct their own knowledge which is affected by the kind of experience they have had and the knowledge they already have or think they have.

Therefore, for being successful while teaching, the teacher has to take into account the previous knowledge and conception of the learners. If this is not done the student makes his own interpretation in the light of existing schema and the result of teaching may not be the same as intended by the teacher. Taking into account the previous ideas of the learners is necessary because the learning outcome depends upon the interaction of the information presented by the teacher, the way it is presented and the existing previous knowledge of the learner. Accordingly, the conclusion drawn from an observation are not unique but depends upon mental ecology of the learner. The major tenets of the constructivist philosophy could be stated as the following :

- Construction of knowledge is a life long effortful process. It begins with the birth and all our knowledge is the result of our efforts at constructing it (Mestre, 1991).
- Knowledge construction is a constructive or generative process and each individual's knowledge is idiosyncratic (Fisher & Lipson, 1986).
- Development of alternative frameworks or misconceptions is from the same mechanism that leads to the development of conception. In addition, some modes and sequences of presenting information during teaching may result into development of misconceptions (Eylon & Linn, 1988).
- Misconceptions may originate as a result of student's interaction and the real world and/or misinterpretation of the world of ideas presented to him/her (Driver & Easley, 1978).
- Due to different conceptual ecology, different learners interpret the same experience/idea differently in their

conceptual structures (Jordan, 1987).

- The process of concept formation is a continuous process of successive approximation and refinement (Fisher & Lipson, 1986).
- Students hold intuitive ideas that are both identifiable and stable, and have enough commonality to make it worth planning instructional starategy (Clough & Driver, 1986).

Designing the Curriculum

In the context of teaching, the Ausubel's statement, 'The most important single factor influencing learning is what the learner already knows; ascertain this and teach him accordingly' (Ausubel, 1968), is well-known. There are many possible ways of implementing this into practice. In the context of constructivist approach, to implement this Driver (1980) has suggested,

> ... Find the alternative viewpoint possessed by the child and provide material in such a way so as to encourage the child to consider or modify these view-points. ...

In practice, it would mean inclusion of the following four points while designing the curriculum (Driver, 1981):

1. Along with paying the attention to the structure of the discipline, it requires to pay equal attention to the structure of thought of the learner. Learning experiences be organized taking these two aspects together.
2. While developing the curriculum, the psychological order of learning be paid attention to. This may not be the same as logical order of presentation of scientific ideas.
3. Learners alternative conception be paid attention to while developing learning activities. These should be such that they provide opportunity to test their own ideas and their implication and compare them with well accepted ideas. At this juncture the conditions to be met for conceptual change – dissatisfaction with the existing conceptions, the new conception must appear intelligible, plausible and fruitful (Posner, Strike, Hewson & Gertzog, 1982) – need to be mentioned.
4. Opportunity must be provided to the learner to think and test the implications of different ideas, because the data and observations presented to the learners may not make these obvious.

To implement these ideas into classroom teaching various suggestions have been given. Out of these major suggestions are as following (Driver, 1985; Driver, Guesne & Tiberghien, 1985; McDermott, 1991; Redish, 1994; Vosniadou, 1994):

- Provide such situations that help to observe, experiment, make and test the hypothesis so that the learner are active in doing science, rather than remembering facts and theories.
- Provide opporunity to explain a phenomenon and discuss it with

fellow learner and defend their own position.

- Learning those ideas that match or are extension of existing mental models/ideas is the easiest. Much of our learning is done by analogy. Therefore, one should focus on students those ideas that are useful for future learning. Students should be given opporunities to manipulate, to test and to revise their mental models on the basis of their experiences.
- The ideas that are inconsistent with the existing mental models are difficult to understand and are likely to give rise to misconceptions. Conceptual changes requiring revision of ontological and epistemological presuppositions are particularly difficult. For this purpose, various teaching techniques such as Socratic dialogue, student discussion, observation/ discussion based on laboratory work could be used. Further, challenging students' ideas through counter examples is also useful.
- New ideas are introduced through intervention, providing instructional material or brain- storming sessions. Ample opportunities must be provided to use new ideas in different situations so that the new ideas become their own.
- Sometimes students find it difficult to seperate new ideas from the context it is presented. Therefore, opportunity to use the idea in many situations is useful to make it context free.
- Certain common difficulties and alternative frameworks be addressed explicitly. This is important because some alternative frameworks are resistent to change.
- It is useful to relate the science concepts with everyday life experiences. Students have often great difficulty in relating concepts and their representations to the actual objects and events.
- Care is to be taken that conceptual change, manner in which it is dealt with in the classroom, is not at the expense of self-confidence, enthusiasm and curiosity of the learners because it may further lead to alienation from science.
- In the introductory courses, it is better to teach fewer topics with depth or understanding instead of many topics at superficial level. Merely presenting correct information is seldom affecting removal of miconceptions.

The following table provides do's and dont's of the classroom teaching in this context.

Elaboration of students' ideas and building of teaching on the existing conceptions is an important feature of constructivist approach of teaching. Many times it requires attempting conceptual change, Many models have been proposed for this purpose (e.g.

Do's	*Dont's*
Encourage students participation through activities, discussion, demonstration, etc.	Pure lecture, no knowledge of students' viewpoints.
Participatory learning, students are active.	Simple transmission of knowledge, passive learners.
Ask students to clarify ideas and state their viewpoints; let the student discuss and/or test implication of their ideas. Help to remove misconception, demonstration and other activities.	Overlook students' ideas. Assume that the misconceptions would be removed as a result of lecture.

Nussbaum & Novak, 1982; Posner et al. 1982; Osborne & Wittrock, 1983; Driver & Oldham, 1986). Essentially these include three steps (Gil Perez, 1996):

- An elicitation phase of pupil's ideas, making them conscious of the plausibility and productivity of those ideas.
- A restructuring phase, creating cognitive conflict, generating pupil's dissatisfaction with their current ideas and preparing them for introduction of scientific conception.
- An application phase which gives opportunities for using the new conception in different contexts and consolidating the new ideas.

A typical such teaching model given by Driver and Oldham (1985) is shown in Fig. 1. It contains five components: (i) Orientation providing sense of purpose and motivation, (ii) Elicitation that provides an opportunity to make the ideas explicit at concious level, (iii) Restructuring consisting of classification and exchange of ideas, exposure to conflict situations, construction of new ideas and evaluation, (iv) Application of ideas to test them in different situations, and (v) Review to compare the existing concepts with the alternatives and have reflective thinking. The focus is on raising such questions as, what do we know about ...? How do we know...? What is the evidence of this ...? What are the gaps in the information? What are the assumptions behind ...? Are the assumptions sensible?

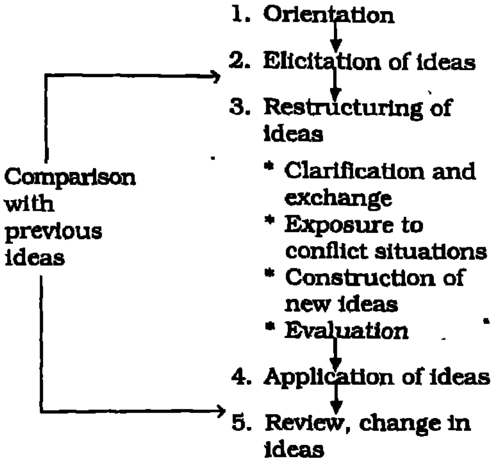
1. Orientation
2. Elicitation of ideas
3. Restructuring of ideas
* Clarification and exchange
* Exposure to conflict situations
* Construction of new ideas
* Evaluation
4. Application of ideas
5. Review, change in ideas
Comparison with previous ideas

Fig. 1: *A constructivist teaching sequence* (Driver and Oldham 1986, Redrawn).

Implications for Teacher Education

The teacher education would consist of those components that could help adopt constructivist approach of teaching, These are in brief as the following:

1. Those teachers having knowledge of student's ideas and plan the teaching in accordance with them become better teachers (Fisher & Lipson, 1986). There-fore, teacher education could contain programme that makes the teachers aware of students alternative framework, its nature and characteristics, In this connection beginning could be made with exploring teacher's ideas itself.
2. Identification of learner's alternative frameworks is an important task in the process of teaching. Teachers require exposure to different strategies that could be adopted for this purpose. Teachers could also be encouraged to evolve their own strategies suitable to their conditions.
3. The strategies to remove alternative frameworks require exposure regarding organization of teaching-learning situations including instructional materials, experiments and specific strategies. This is a more difficult task and much efforts are required in this direction. This would include adoption of different strategies and gauging the effectiveness on the basis of hard data .
4. Teachers also require programmes in content areas that are directed to remove their misconceptions (Saxena, 2000) and help them to become more effective teacher. Again, we have to remind ourselves that mere telling does not help (McDermott, 1984). Teachers could be introduced first to the children's frameworks. This may encourage them to clarify their own concepts and compare these with the scientific viewpoint. This could also involve introduction of possible teaching strategies and sequences that may be effective.

Problem-solving

Why Problem-solving is Difficult?

Problem-solving in science is a difficult task for many students despite years of classroom learning. Many times they are able to give the required theory correctly and completely but find it difficult to solve a new problem based on theory they know so well. Examination of student's response to the problems shows variety of reasons for this such as, they

- do not understand the problem very well;
- do not know where to start;
- look for useful formula without understanding concept behind it;
- solve the problem mechanically without understanding the solution;
- solve the problem comparing with the solution of another problem

which is conceptually not comparable and is similar superficially;

- confuse with mathematics of a problem with science of the problem;
- fail to identify nonsense answers;
- do not have procedural knowledge;
- are confused by signs of various quantities such as velocity, acceleration, force, etc.;
- do not know how to choose convenient coordinate system;
- are not able to apply the theory they know well.

Many attempts (e.g. Adamovic & Hedden, 1997; Bolton, 1997; Heller, Keith & Abderson, 1992; Heuvelen, 1991; Huffman, 1997; Reif, Larkin & Brackett, 1976; Zajchowski & Martin, 1993) have been made to understand the problems of problem-solving and to develop the strategy to help learning of problem-solving. For example, Ausdal (1988) proposed structured method of problem- solving in Kinematics. Another similar attempt was by Adamovic and Hedden (1997). In both these approaches, the steps of problem-solving are too specific and could help the children to solve the routine problems only and there is little scope for creativity required to solve novel problems. The approach is based on algorithmization of problem-solving.

Another approach is based on observation and comparison of the way experts and novices approach and solve a problem (e.g. Larkin & Reif, 1979; Camacho & Good, 1989). It was observed that (i) experts tend to view the problem qualitatively on the basis of fundamental concepts whereas novices look for the mathematical equations that could be relevant, (ii) experts engage in more planning than the novices, (iii) experts develop the plan of attacking a problem, whereas novices attempt to solve a problem on the basis of superficial impression of the problem, (iv) experts solve the problem in a more organized and logical manner, and (v) when experts know the solution of a problem they tend to work forward whereas when they face a problem they do not know the solution immediately they tend to solve equations algebraically by working backward starting with the unknown variables to be found (Huffman, 1997). Moreover, successful subjects exhibit several behaviour such as they read the whole problem and then restate the problem in their own scientific language; they not only use the symbols properly and pertinent to each problem but invent their own symbols when needed; they use two methods to solve the problem and / or to check their answer and reasons; they use several assumptions and approxi-mations adequately to simplify the solution to the problems and they apply several principles successfully (Camacho and Good, 1989). Zajchowski and Martin (1993) observed the differences in the problem-solving approach of stronger and weaker novices and found that the knowledge of the weaker novices appears to be organized and applied according to specific formulae and procedures familiar to them. The stronger novices persist with the problem more than the weaker novices in the face of difficulties in solving a problem.

What is a Problem?

It is relevant to discuss, what constitutes a problem. The important features of a problem are existence of a situation, with at least some amount of difficulty in finding its solution. The solution of the problem should not be obvious and it is task that requires leading from the given situation to a final target position. The amount of difficulty faced in solving a problem is not absolute in magnitude and depends upon the background of the solver-expert or novice (Gil-Perez et al., 1990, Reif, 1995).

In a traditional classroom teaching, typical end-of-the-chapter textbook problems are used. They provide ideal situation (e.g. no air friction, smooth surface, etc.) that have no connection with real life. Such problems encourage equation-based problem-solving approach. As a contrast, real life problems do not describe ideal situation and require creative problem-solving method. Heller and Hollabaugh (1992) call such problems as context-rich problem and identify them with the charac-teristics: (i) They do not explicitly identify the unknown variables; (ii) some information required to solve the problem may be missing and needs to be estimated from common knowledge and taking approximations; and (iii) there may be some information that is not really required to solve the problem.

Steps of Problem-solving

The major steps of problem-solving are (i) Analysis of the problem; (ii) Construction of the solution; (iii) Checking the solution; and (iv) Revision, if required (Reif, 1995). Many times it is found that students do not understand the problem clearly and completely. Moreover, they also need to understand the concepts involved in the problem. Reif et al (1976) describes in detail the abilities encompassed by understanding a relation. Elaboration of concepts and relations on similar lines would help solving the problem. The major steps of problem-solving are further elaborated by many authors (e.g. Bolton, 1997; Heller, Keith & Anderson,, 1992; Henvelen, 1991; Reif, 1995 A). The following are illustrative steps of problem-solving:

1. *Analysis of the problem*
   (a) Looking at the problem as a process: What is happening? What are initial and final conditions?
   (b) Understanding the problem:
      (i) Identify the known and unknown quantities.
      (ii) Identify special conditions : no friction, no transfer of energy, conservation of charge, etc.
      (iii) Pictorial representation of the problem from beginning to the end – diagram, graph, free body diagram, forces acting on different bodies, circuit diagram, ray diagram, etc.

2. *Solving the problem*

   (a) Reason qualitatively about the process: Identify concepts, principles, conservation laws, etc. involved. Construct law details of the physical problem, locate forces, other affecting factors.

   (b) Mathematical representation of the problem: choose sub-problems, options, wise choice of coordinate system, check as many equations as many unknown, solve equations.

3. *Checking the solution*

   All wanted found, units, magnitude, direction, self-consistent; sensible values, special cases, alternative solutions, clarity of solution; consistency with other known results.

4. *Revision, if required*

Alternatively, Bolton (1997) suggests five steps: preparation, brainstorming, checking the equations, working phase and checking the solution. In the preparation phase the problem is viewed closely qualitatively and data is identified; in brainstorming phase tools for the job are assembled without much thought on their use; in checking the equations the number of equations is checked, if it is in minimum sufficient number, equal to number of unknown variables. Moreover, Bolton (1997) also uses special tips on topics such as, how to make wise choice of coordinates, planning to eliminate unwanted variables, how to find energy associated with a given stationary state. To understand the problem well, Heuvelen (1991) emphasizes on pictorial representation, graphical representation and mathematical representation of the problem. They also give importance to understanding of quantities that occur in the problem and diagrammatic representation because many students do not understand them well enough.

Teaching Problem-solving

Many approaches have been used to teach problem-solving effectively. Following Heller, Keith & Abderson (1992), Huffman (1997) compared the results of 'explicit problem-solving strategy' and 'textbook problem-solving strategy' and found that explicit strategy improved the quality and completeness of student's physics representation more than textbook strategy.

Heuvelen (1991A) used overview case study (OCS) Physics approach. It integrates conceptual understanding and problem-solving in teaching of physics. Specifically, it includes (i) confrontation of misconceptions; (ii) instructions in skills of problem-solving used by experienced physicist; (iii) help to integrate the knowledge into a comprehensive hierarchical structure built around basic concepts; and (iv) repeated exposure to concepts and analytical techniques. The results indicate gains in problem-solving ability from better conceptual understanding.

While teaching problem solving the following is suggested:

- Emphasis to be laid on primacy of the information relation to fundamental formulae and concepts. The use of non-fundamental formulae is to be discouraged (Zajchowski & Martin,1993).

- The classification of the problem according to the underlying principle be emphasized (Mestre, 1991; Zajchowski & Martin, 1993).
- Some pre-requisite skills to be learnt to the point of automaticity, so that more attention and memory energy be used for problem-solving.
- If transfer and problem-solving are in structional objectives, then students ability to apply what they have learnt should be evaluated.

Conclusion

Undersrtanding basic concept of science and learning to develop skill of problem-solving are two very important components of understanding science and these have been dealt here. It shows that serious concerted effort is required on the part of teacher to achieve these objectives. However, the typical textbook, end-of-the-chapter evaluation test items and end-of-the-term session evaluation question do not appear to give importance to these aspects. Typically, they emphasize rote memory and repeating the information the way it has been given in the textbook. Unless suitable changes are not made in this part, it is difficult to break the ice.

Teaching of concepts involves dealing with the student's existing ideas and building the conceptual structure on it. Constructivist approach is a powerful approach but using it in the classroom would require change in teaching and evaluation strategy. Dealing with problem-solving is a difficult area of research and some insight has been gained in this direction. Teaching of problem-solving involves emphasis on steps of problem-solving. However, much work needs to be done to evolve a well articulated strategy.

Some Common Misconceptions Reported in the Literature

1. *Mechanics*

- If a body is moving, net force is acting on it in the direction of motion. Conversely, if there is no force there will be no motion.
- Motion takes place in the direction of applied force.
- A stationary object cannot exert a force.
- A body moves forward as long as push is not dissipated.
- Acceleration is also zero when velocity is zero.
- Heavy body falls faster.
- Table does not exert force on a body kept on it.
- A stone is attracted by the earth but it does not attract the earth.
- Friction occurs only between moving surfaces.

2. *Models of Earth*

- Flattened sphere
- Hollow sphere
- Dual earth
- Disc earth
- Rectangular earth

3. *Electricity*

- *Clashing current model* : Currect flows out from each battery terminal, collides to produce the observed phenomena such as heat and light.
- *Attenuation model* : Current leaves the battery from one terminal, is partly dissipated in the bulb, its unused part returns to the battery through other terminal.
- *Sharing model* : Each of several components receives its share of the current; identical components receive and consume identical currents.
- *Unipolar model* : there is no current in the return path; essentially only one terminal of the battery is regarded as active.
- In a series circuit current is not same at all the points.
- Battery is constant current source.
- Higher resistance produces more heat.
- Failure to recognize resistors connected in series and parallel.

4. *Light*

- Half lens forms half image.
- To see an object, it is not necessary for light to enter the eye.
- The process of vision of an object is not understood. To some children, light does not get reflected by the object before reaching the eye.
- Light does not exist unless it is intense enough to produce perceptible effects.
- Light is not necessarily conserved; it can disappear or appear at certain points without any perceptible reason.
- Light is not in the empty space.

5. *Heat*

- Bodies of different materials kept in a room are at different temperatures.
- When a body is heated, its temperature always rises.
- Water and steam at the same temperature contain same amount of heat.
- Heat is a kind of substance, residing in objects which can move through them and can pass from one to another.

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Mathematics as Communication of Ideas

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The National Council Teachers of Mathematics (NCTM, 1989), USA states the following pertaining to mathematics as communication:

> Mathematics can be thought of as a language that must be meaningful if students are to communicate mathematically and apply mathematics productively. Communication plays an important role in helping children construct links between their informal, intuitive notions, and the abstract language and symbolism of mathematics; it also plays a key role in helping children make important connections among the physical, pictorial, graphic, symbolic, verbal, and mental representations of mathematical ideas. When children see that one representation, such as an equation, can describe many situations, they begin to understand the power of mathematics; when they realize that some ways of representing a problem are more helpful than others, they begin to understand the flexibility and usefulness of mathematics.

Mathematics for the public school student needs to be perceived as a language used in communication. Thus in situations such as the following ideas are being communicated in school and in society:

1. When adding, subtracting, multiplying, and dividing.
2. When measuring to determine distance, perimeter, area, and volume.
3. When determining ratio and proportion.
4. When performing operations on fractions, mixed numbers, and decimals.
5. When seeing patterns and relationships in mathematics.
6. When engaging in critical and creative thinking, problem-solving, as well as logical thinking in ongoing lessons and units of study.
7. When hypothesizing and estimating in the curriculum.
8. When working in small groups and in large group instruction.
9. When writing and stating orally word problems in mathematics.
10. When quantitative ideas are expressed in every day situations in life (See Ediger, 2000, 101–103).

Communication of content in mathematics then becomes vital. Each student should become proficient in communication skills. Mathematics has a language of its very own, such as in the following number sentence: 236+384 =384+236. Mathematics also has a language that cuts across the curriculum. For example, there are numerous library books written for students that pertain to mathematical ideas, but may also include science, history, geography, and economics, among other academic disciplines.

Assisting Students in Mathematical Communication Skills

How might teachers assist students to improve skills in communication? First, students individually need to be neat and accurate in written work. Students need assistance to form numerals and symbols in mathematics legibly. If the teacher needs to guess and spend much time on determining what has been communicated on paper by an individual student, then ideas have a difficult time in being received by others. At a young age and sequentially, the mathematics teacher needs to assist students to develop clarity in written work. Students need to perceive mathematics as communication. One is communicating content to others in writing (See Gardner, 1993, on interpersonal and intrapersonal intelligence). Being able to work effectively by the self as well as with others is important!

Second, a committee of students may work cooperatively to develop word or story problems that relate directly to the lesson being studied. Incorporated into the written work is correct spelling of words, proper grammar and usage, clear and distinct ideas, appropriate sequence of ideas, as well as punctuation marks. Thus, omitting commas may well make for misunderstandings of the word problem by the reader. The following is an example: At the picnic, they had ham sandwiches, jello salad and milk. How many kinds of food were served at the picnic? It certainly is vaguely punctuated to ascertain how many different foods were served. Rewriting the sentence, the following are possibilities:

1. At the picnic they had ham, sandwiches, jello, salad, and milk. Five different kinds of foods are mentioned here.
2. At the picnic they had ham sandwiches, jello, salad, and milk. Four foods are mentioned.
3. At the picnic they had ham sandwiches, jello salad and milk. Three foods are mentioned.

By observing and discussing the importance of punctuation marks in sentences, each student may definitely see their need for accuracy of and in written mathematical communication.

Third, students need to be able to interact well with others in solving a problem in mathematics; students also need to be good listeners. Sometimes, a student interrupts others in a discussion and may fail in listening to others. Turning off on what has been said can make for a lack of achievement in ongoing lessons and units of study. The mathematics teachers need to assist students to develop quality standards of listening. These standards become objectives for student achievement. When supervising student teachers over a thirty year period of time, many teachers listed standards such as the following, for good listening:

1. We try to avoid repeating statements in class due to poor listening habits.
2. We give everyone a chance to participate in ongoing discussions.
3. We do not interrupt others who are sharing ideas in discussions.
4. We respect each idea presented.
5. We do not ridicule the thinking of others.
6. We speak clearly in discussions so that good listening my result.
7. We encourage others to participate in discussions.
8. We work together to think creatively and critically in brain storming sessions.
9. We assist the group to identify and solve problems in mathematics.
10. We are polite to each other (Ediger, 2000, 114-119).

Standards may be added or deleted as the need arises. Students should have input into developing criteria for effective listening. When there is input from students, there is a better chance for learners to accept each standard. It is necessary to assess frequently if the adopted standards for good listening have been achieved by students.

Reading as Communication in Mathematics

Communication in mathematics is certainly aided when students increase reading skills and abilities. Realistic goals need to be established for reading in the mathematics curriculum. Thus, the objectives are challenging, but not too difficult to preordain failure. Nor, should they be so easy that mathematics becomes boring. There are many reasons why students do not do well in reading mathematical content. Among others, the following are salient to consider:

1. A lack of phonics skills to associate sounds with symbols to unlock unknown words.
2. A lack of syllabication skills to divide words into recognizable parts before synthesizing for meaning.
3. A lack of using the illustrations on a page to help identify unknown words.
4. A lack of knowledge of the structure of the language being used in reading mathematics subject matter.
5. A lack of motivation in wanting to learn to read.

The mechanics in learning to read, as listed in items 1-4 above, are tools to use in identifying and recognizing unknown words as well as a key or foundation to use in reading. Tools in reading are to be used to attach meaning to the ongoing subject matter to be read. To guide students to read subject matter with comprehension and understanding makes for improved communication. The following need to be stressed by the mathematics teacher to emphasize reading as communication:

1. Reading for vital facts, concepts, main ideas, and generalizations.

2. Reading to apply subject matter, analyze, synthesize, and assess ideas read.
3. Reading to relate content read to integrate subject matter across the curriculum.
4. Reading to gain information to answer questions and solve problems in mathematics.
5. Reading to separate vital information from that of lesser value in solving word problems (Ediger, 2000, 2).

There are numerous methods of reading instruction that may be used to assist student comprehension of subject matter. These should be used in mathematics as the need arises to encourage optimal achievement:

1. The Big Book approach.
2. Echoic reading.
3. Basal textbook procedures.
4. Teacher/pupil planning of objectives, learning opportunities, and assessment procedures.
5. Learning centres method.
6. Laboratory approaches.
7. Enrichment corners to provide for individual differences.
8. Performance objectives in mathematics.
9. Problem-solving based on realistic mathematical problems in society.
10. Computerized programmes such as drill and practice, tutorial, gaming, simulation, as well as diagnosis and remediation (Ediger and Rao, 2000, Chapter Three).

Each of the above named methods may be used to assist students to achieve optimally in mathematics. No procedure should be used for the sake of doing so, but rather to help each student to learn as much mathematics as possible.

Philosophy of Instruction

There are numerous philosophies which might well provide guidance to teachers in developing the mathematics curriculum. Essentialism stresses that teachers select what is basic to learn in mathematics for students. The basal textbook is an example of essentialism in the mathematics curriculum. Second, existentialism advocates students being heavily involved in making choices and decisions in terms of what to learn. Learning centres and learning corners provide opportunities for students to choose from among alternate activities to pursue. Third, realism with its emphasis upon students achieving predetermined measurably stated objectives would be inherent in state mandated programmes in mathematics as well as in computerized programmes involving drill and practice, tutorial, gaming, and diagnosis/remediation. Fourth, experimentalism with its problem-solving approaches was a key component of John Dewey's philosophy of teaching (1916). Dewey, a leading philosopher of education, in his laboratory school at the University of Chicago, stressed the following flexible steps in problem solving:

1. Identifying and delimiting the problem.
2. Securing information in answer to the problem with the use of a variety of procedures.
3. Developing an hypothesis.
4. Assessing the hypothesis in a life-like situation.
5. Modifying, revising the hypothesis if necessary.

It might well be that an eclectic position may need to be used by the mathematics teacher in terms of choosing philosophies to implement in the instructional arena. Certainly, there is room for the basics or essentials as contained in a carefully chosen basal text, or in a multiple series used. Then too, the author believes strongly in having students being involved in choosing selected learning opportunities, from among alternatives, as existentialists recommend. State mandated objectives tend to require the use of predetermined precise objectives for students to attain. Realism, as a philosophy of education advocates that precision in stating objectives provides feedback to the teacher/learners if achievement of the stated ends has/has not be attained. Experimentalism is a practical philosophy in that life-like situation should provide the basis for the mathematics curriculum with a problem solving emphasis. The author recommends balance among these four philosophies of education in teaching mathematics to students and thus stress communication of ideas as a key component of instruction.

Improving Communication Across School Borders

There are numerous borders beyond the classroom, school, and school system boundary in assisting quality communication (See Bradshaw, 2000). A very important border is that of the parents or guardians. Thus, the home setting can do much to assist students to learn as much as possible in mathematics. What can the home do to provide for more optimal student learning in mathematics?

1. Speak positively about the school curriculum. Do not ridicule or minimize what the school is attempting to achieve.
2. Speak to the teacher if problems or misunderstandings arise. Try to identify and solve involved problems.
3. Assist offspring with homework on mathematics, as needed.
4. Discuss with the learner in the evening what was emphasized and achieved in an ongoing mathematics lesson or unit.
5. Do not assume that nothing was learned when a student says, "Nothing" to the question, "What did you learn today?" Learners usually want to talk about other things for recreation and relaxation.
6. Ask the teacher for suggestions on teaching-problematic facets of mathematics.
7. Work together with the teacher to provide for a quality student centred mathematics curriculum.
8. Learn mathematical ideas with the offspring as he/she does homework.

9. Encourage student achievement and do not make negative comments about the offspring and his/her capabilities in learning mathematics.
10. Use mathematical ideas in the home setting such as in measuring ingredients that go into the making of a home cooked food item (Ediger, 2000, 16-19).

In Closing

Students need the best mathematics curriculum possible to achieve well in school and in society. Competency in the mathematical world is a must to function well in the local environment and later at the work place. Continuous study of the objectives, learning opportunities to achieve these ends, as well as appraisal procedures need to be ongoing. Each student needs to achieve as much as possible. Heuser (2000) advocates the following guidelines for teachers to use in teaching students in ongoing lessons and units of study:

1. Children being actively involved in mathematics activities.
2. Children developing depth understanding of mathematics by being encouraged to construct their own knowledge.
3. Children benefiting from choosing activities and being motivated to work at an optimal level.
4. Children needing time and encouragement to reflect on and communicate their understanding. By writing, speaking, and drawing what they learned, students conceptual understanding increases.
5. Children needing adequate time and experience to construct mathematical knowledge.

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Assessment of the Performance of Senior Secondary Students in Essential Skills of Chemistry Practicals

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Practical work plays a central role in teaching of chemistry (Fuhrman et al., 1982). Main aims of practical work in chemistry are to: (i) make accurate observation and describe chemical phenomena; (ii) develop specific manipulative skills; (iii) practise identifying problems relating to chemistry and seeking ways to solve them; (iv) develop logical reasoning; (v) develop self-reliance; (vi) verify principles and facts already learned; (vii) develop certain disciplined techniques; (viii) develop a critical attitude; and (ix) be able to comprehend and carry out instructions (Okebukola, 1987). However, most of the teachers in developing countries consider practical work just to verify scientific knowledge (Mark et al., 1993) and give little attention to the development of practical skills in students in their assignments and assessment. Keeping in view the importance of developing practical skills and their assessment, the present study was undertaken.

Objective of the Study

1. To find out the level of performance of the students in the skills of following institutions for carrying out practical work, reporting of the observations/measurements and interpreting and concluding.
2. To find out the differences in the performance of boys and girls in different skills.

Methodology

A practical task from senior secondary chemistry practical syllabus; to find out the molarity of a given potassium permanganate solution by titraling against M/20 ferrous ammonium sulphate, was administered to 38 students (23 boys and 15 girls) of Class-XII of a Kendriya Vidyalaya located in Bhopal (M.P.). Instructions for performing the experiment were given well in advance in the class by the teacher. The students were to perform the experiment as per the instructions given for the use of apparatus and materials, taking observations, reporting observations, interpreting data to reach valid conclusion.

To find out the levels of performance of students in different skills, a proforma was developed that was similar in some respects to that used in IEA Second International Science Study (Kay et al., 1992). The proforma contained the following points for answering.

1. Describe how you set up the apparatus, use the apparatus,

different solutions and indicator and took observations.

2. Report your observations in a suitable format.
3. Give calculations and draw result.

The scoring scheme developed by the authors was as given below.

1. Skill of following instructions for carrying out practical work.

(a)	Setting the apparatus	1 mark
(b)	Using the apparatus	1 mark
(c)	Using the materials	1 mark
(d)	Taking observations	1 mark
		4 marks

2. Skill in reporting

(a)	Presenting the observation in suitable format	2 marks
(b)	Using correct scientific language	2 marks
		4 marks

3. Skill in interpreting and concluding

(a)	Making correct calculations	3 marks
(b)	Giving result	1 mark
		4 marks

In order to minimize the inter-rater variability, the whole marking task was done by only one investigator.

Results and Discussion

Table 1 summarizes the results for three practical skills. A perusal of Table 1 indicates that the average score in each skill is more than 70 per cent. This implies that in the skills of following instructions, reporting and interpreting and concluding, the students have achieved high level of mastery. The main factors, contributing to such a high score seem to be: (i) the learning environment in the Kendriya Vidyalaya is comparatively better, (ii) highly qualified teachers are appointed in these schools, (iii) senior secondary, being a terminal examination for going to the higher studies, motivational level of the students is very high. Table 2 shows that the boys had scored higher in case of interpreting and concluding while girls in other two skills. However, in no case, the difference is statistically significant at 0.01 level. In the present study, findings in case of the skill of following instructions for carrying out practical work, show the same trend as in case of Scottish data (Robertson, 1987) but in the case of the latter studies, the performance of girls was significantly superior to boys. In case of skill of reporting (Lock 1992), had found no gender related difference which is in full agreement with the findings of the present study. Gender based studies on the skill of interpretation suggest that some differences exist between the performance of boys and girls (Jonson and Murphy, 1986; Lock, 1992). Boys perform better than the girls. In the present study also same trend is observed; boys showing superior performance but superiority does not have statistical significance.

Implication of the Study

The study indicates that the students have acquired appreciable mastery in the skills of following the instructions, reporting and interpreting and

TABLE 1
Performance of the Students in Different Skills
(Number of students : 38)

Skill	*Mean*	*Standard deviation*	*Maximum possible score*	*Per cent score*
Skills of following instructions in carrying out practical work	2.97	1.45	4	74.25
Skill in reporting	3.04	1.90	4	76.00
Skill in interpreting and concluding	2.84	2.20	4	71.00

TABLE 2
Comparison of Performance of Boys and Girls in Different Skills

Skill	*Boys (N = 23)*		*Girls (N = 15)*		*Maximum possible score*
	Mean	*S.D.*	*Mean*	*S.D.*	
Skill of following instructions in carrying out practical work	2.90	1.46	3.74	1.20	4
Skill in reporting	3.00	2.01	3.10	1.88	4
Skill in interpreting and concluding	3.10	2.18	2.44	2.12	4

concluding. On the strength of the findings of this study it is worthwhile suggesting that no gender related assumptions should be made in practical work in respect of above skills as girls and boys perform nearly equal.

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A Study of Class VII Students' Understanding of Science and Their Process Skills in Relation to Ability to Apply Science in Daily Life

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The important factors that affect the development of a country are: level of scientific and technological knowledge of its citizens including the latest trends and the ability to apply or adopt them in daily life. For this the curriculum must be in conformity with the aims and objectives of teaching science. Objective-based teaching of science (or any subject) lays stress on various types of learning outcomes achieved among children rather than more memorization of facts. In this approach after the knowledge and understanding levels of objectives next level in hierarchy comes the application of concepts in new situations. More than any other subject there is plenty of scope for applying ideas and concepts of science in the daily life of students. Any science curriculum and its transaction become meaningful and fruitful only when students are able to apply at least some of the science concepts in their daily life. Otherwise their knowledge of science remains bookish, sterile and irrelevant in their lives (Liam McAleese & Ruth Jarman, 1992). Even in later life when they occupy important positions in society and are confronted with many social and national problems they may fail to see the relevance of the scientific approach.

Knowledge and understanding of science provides the base which may facilitate students to apply it in their daily life. Understanding presupposes knowledge, which is placed as the first step in the hierarchical classification of instructional objectives, according to Benjamin Bloom. As a step towards acquiring the skill of applying science concepts in daily life students are expected to understand the basic concepts.

Most of the time the major emphasis of science teaching is on the subjejct matter to be learned and memorized. The objective that children must understand and appreciate the processes of science or develop the processes skills on science, is often neglected. It is through the exercise of these process skills that products of learning a particular subject are generated: definition, meaning and explanation of terms, concepts, principles, procedures, laws, theories, etc, in the domain of that subject. The American Association for the Advancement of Science (AAAS) rejects the idea that science is only a collection of facts. They hold that the major goal of science is to develop child's skill in using the processes of science.

Process skills are the way in which the products of science were formulated, it is the means by which the body of knowledge is acquired. It can give the pupil a valid understanding of the nature of science. Through this the child can experience the excitement and frustration that are a part of science and can better understand its product.

Despite the dearth of research examining the use of science in daily life, the survey conducted by Liam McAleese and Ruth Jarman(1992) on children's reported use of school science in their everyday life found that majority of students involved in the survey had found their science accessible and usable in contexts beyond the classroom, they were also willing and able to articulate their experiences often in interesting ways.

Ebbut and Watts (1987) have conducted a study which bears upon the issue of the use of 'science in day-to-day life'. The students involved in the study provided examples of how they had used their science in everyday lives. On the whole the students do not perceive their science experiences as in any concrete sense contributing to their capability in the real world.

Lave (1988) and Harris (1991) have done investigations in the area of relationship between computational skills as they have learned in school and as they are practised in everyday situation.

Bhatt (1983) developed the test of process skills as an instrument to assess achievement and diagnose weakness in understanding of science processes by the students of Class VIII in Kendriya Vidyalayas and found that processes like observing, comparing and classifying are developed more than the processes of inferring and predicting.

Menon (1986) conducted a study of a system of science education in the perspective of the process of science in inquiry, he found that the overall proficiency in the process skills steadily increased as students went up from,one class to the other.

Furnham (1992) has undertaken an investigation which is associated with the increasingly eloquent research into the public understanding of science. This study seeks to investigate how adults appropriate and adapt science to meet the demands of the situations.

Widen (1975)made a comparative study of the Students' Outcomes of Science — A Process Approach (SAPA) and traditional science teaching. Both groups were taught with respective methods and result indicated that students exposed to SAPA do better on cognitive, process-oriented tasks than traditional classroom task.

Howe and Mierzwa (1977) emphasize that shift from content acquisition to use of science process as indicative of logical thinking, and found that appropriate classroom instructions can increase the level of logical thinking.

As the studies cited above indicate, none of them are found to link science application ability with science understanding and science process skills. These studies do not seek to find out the influence of the factors like SES, locality, sex and medium of instruction on science application ability.

The present investigation is planned around the factors, science application ability, process skills in science and understanding of science. It assesses how far children possess the ability to apply science in new situations and then based on the findings, possible remidies can be suggested in the teaching-learning process of science. The study also assesses the process skills and understanding of science of the students. An attempt has also been made to find out the relationship of science application ability with the level of understanding of science and science process skills. The study probes into how science application ability is influenced by the factors such as, SES, locality, medium of instruction and gender.

Objectives

1. To find out the students' ability to understand the science topics taught to them.
2. To find out the students' level of process skills in science.
3. To find out the students' ability to apply science in daily life.
4. To find out the relation between science application ability and science understanding.
5. To find out the relation between science application ability and science process skills.
6. To find out the influence of SES, locality, medium and sex on science application ability of students.
7. To find out whether the students with high, medium and low process skills will differ in their ability to apply science.

Hypotheses

1. There is no relationship between the science application ability of Class VII students and their understanding of science.
2. There is no relationship between the science application ability of students and their science process skills.
3. With respect to science application ability there is no significant difference between the performance of students grouped according to high, medium, and low SES.
4. There is no significant difference between rural and urban students in their science application ability.
5. There is no significant difference between girls and boys in their science application ability.
6. There is no significant difference between Malayalam and English medium students in their science application ability.
7. With respect to science application ability there is no significant difference between the performance of students grouped according to high, medium, and low process skills.

Sampling

The present study is carried out in Koyilandy taluk of Calicut district, Kerala State. There are four revenue divisions in this taluk. Out of the four regions, Permbra region and balussery region of the taluk were selected for the study randomly. The total number of upper primary schools in this area is 42. The sample population was drawn from Class VII students in these schools for which six schools were selected randomly. A total of 180 students of Class VII were selected randomly from the six schools, using cluster random samplint method.

Tools Used for the Study

The following tools were constructed and validated by the investigator.

1. A test to assess the understanding of Class VII students in science topics taught them.
2. A test for assessing the ability of students to use science in daily life.
3. A test to assess the process skills in science of Class VII students.
4. SES scale.

The investigator had used Kuppuswami's scale of socio-economic status modified and updated by A.C. Josy as the guide for the M.Ed. dissertation (Nadaf 1997).

Procedure

The students are administered the three science related tests and also the SES scale along with them.

Data Analysis and Results

The reliability of the tests calculated by using split half methods is found to be quite good (Science Application Ability r=0.843, Science Understanding r=0.872, Science Process skills r=0.920). Descriptive statistics is used to present a description of the performance of the students in different tests. Inferential statistics (t-test, ANOVA ,etc.) is used to test the hypotheses and to draw inferences.

The mean value represents the overall performance of the group as a whole. Here the mean value for the variable 'science understanding' is 42 per cent of the maximum score, Thus, it is possible to say that the performance of the group as whole is a little below average. The mean score of the 'science

TABLE 1

Mean and Standard Deviation of Science Understanding, Science Application, and Science Process Skills.

Variables	*Maximum Score*	*Mean*	*Standard Deviation*
Science Understanding	15	6.354	2.917
Science Application	20	8.420	3.435
Process Skills	20	9.466	3.588

process skill' is 48 per cent of the maximum score, which shows that the overall performance is just average. The 'science application ability' acquired by students and manifested through the test is moderate as shown by the mean score, which equals 42 per cent of the maximum score.

TABLE 2

Correlation Values of Science Application Ability with Science Understanding and Science Process Skills.

Variables	*'r' value*
Science Application Ability with Science Understanding	0.537
Science Application Ability with Science Process Skills	0.521

The 'science application ability' of students and 'science understanding' are related positively and the relation is moderate and quite significant. The science application ability of students is moderately related to their science Process skills and the relation is positive and significant.

The students belonging to high, medium and low SES show a significant difference in science application ability. There is a significant difference between the medium and low SES group. Medium SES group performed better than the low SES group. There exists a significant difference between the high and low SES group. High SES group performed better than low SES group. There is no significant difference between high and medium SES groups as shown by the 't' value.

It is observed that there exists a significant difference between the urban and rural students in science application ability. Urban students' performance is better than rural students.

TABLE 3

Mean, Standard Deviation and One-way ANOVA: Science Application Ability Based on SES

Groups	*N*	*Mean*	*SD*	*'f' value*	*'t' value*
Low SES (L)	46	6.797	2.943	12.238	HM-1.775
Medium SES (M)	81	8.123	3.756		ML-2.88*
High SES (H)	53	10.289	3.792		HL-7.542*

*Significant

TABLE 4

Mean Standard Deviation and 't' test: Science Application Ability (Urban, Rural)

Region	*Mean*	*SD*	*'t' value*	*N*
Urban	0.377	3.912	2.311*	60
Rural	8.016	3.628		120

*Significant

TABLE 5

Mean, Standard Deviation and t-test: Science Application Ability (Boys and Girls)

Sex	*Mean*	*SD*	*'t' value*	*N*
Boys	8.488	3.768	0.065	90
Girls	8.451	3.792	90	

The mean score of boys is almost equal to the girls. As shown by the 't' value, the science application ability of boys and girls do not differ significantly.

TABLE 6

Mean, Standard Deviation and t-test: Science Application Ability (Medium of Instruction

Medium	*Mean*	*SD*	*t-value*	*N*
English	9.044	3.775	1.445	60
Malayalam	8.183	3.749	120	

No significant difference is found between the performance of Malayalam and English medium students.

The science application ability of the three groups based on science process skills have shown a significant difference. There is a significant difference between medium and low process skill group. The medium group performed better than the low process skill group. There exists a significant difference between high and medium process skill group.High group performed better than medium process skill group. High and low process group differed significantly. High process skill group performed better than low process skill group.

Discussion

This study reveals that the overall performance of the students in science application ability, science understanding and science process skills are not so good. Their performance is just average .We do not know how far this is true regarding other parts of Kerala. Even then teachers, parents and educationists should consider this factor, and provisions should be made for developing these science related abilities. Ways should also be found to develop interest and positive attitude towards science.

In this study it is revealed that there is a relation between science application ability and science understanding. It is

TABLE 7

Mean, Standard Deviation and One-way ANOVA: Science Application Ability Based on three Process Skill Groups.

Groups	*N*	*Sum*	*Average*	*SD*	*f-value*	*t-value*
Low (L)	54	231.75	4.291	2.603	26.98	LM-8.02*
Medium (M)	75	513.75	6.850	2.382		HM-2.99*
High (H)	57	398.25	7.808	2.786		HL-10.07*

*Significant

clear from this that science understanding is the base using which students can apply science in daily life. So provision should be made in science curriculum and teaching that students are thorough with the scientific terms, factors, concepts, etc. along with the variety of ways in which some of them can be applied in daily life.

Another finding is that science application ability is related to science process skills and high process skill groups are showing higher ability to apply science in daily life. Educators, teachers and parents should engage children in the higher thinking process, while they learn any subject and the science process skills while students learn science.

The study also brings to light the fact that the performance of rural students are not good when compared to urban students in their science application ability. In order to improve their application ability, provision should be made in the rural area, like science exhibition, quiz, field work, projects, etc. with a thrust on daily life application. Girls and boys did not differ in their performance in science application ability. Gender is not found to have any influence on science application ability. There was no significant difference between Malayalam and English medium students in their performance in science application ability. This gives a result contrary to popular expectation and belief that English medium students perform better than Malayalam medium students in school subjects like science.

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Rhythmic Chemistry/ Singing Chemistry

I, II and III Periods and I and II Groups of the Periodic Table

H							He
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar
K	Ca						
Rb	Sr						
Cs	Ba						
Fr	Ra						

Poem for the Above Periodic Table

Hey Henry !
Lisa went to **Be B**ylon's Church
did **NOt Find Nency** there
Nany Managed All SimPle efforts
To **Search** for her in **Cloudy** we**A**ther
So where had Nency gone?
She was playing with **Kitten** of **Cats**
And **Ruby** Srishti **Caesy Baby**
Friends with **Rats**

IV, V, VI Periods of p-Block

	IIIA	IVA	VA	VIA	VIIA	VIIIA
4th pd	Ga	Ge	As	Se	Br	Kr
5th Pd	In	Sn	Sb	Te	I	Xe
6th Pd	Tl	Pb	Bi	Po	At	Rn

Poem for p-Block Elements

In the **Garden** Bos **Gently** asked **Asked** his P.A.
To **Search** for the **Brown** **Krape** paper
In **Sane** Binny was quite **Stubborn**
He Took the **Tea** and Ignored Mr. **Xen**
So what was the fate of Binny ?
Bos **Typed** a letter, and on **Public** ground
Binny was **Posted** **At** **Ram** **nagar**

d-Block (Transition Elements)

	IIIB	IVB	VB	VIB	VIIB	→	VIIIB		IB	IIB
4th pd	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
5th pd	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd
6th pd	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg

Poem for the above Period Table

Scholar Yenny Laughed and laughed
He **Tied** a knot between **Zero** & **Half**
Half had the **View** he was **Nawab** of **Taiwan**
Zero thought of Crown of **Modern WoMan**
So what happened next?
Angry **Teacher ReFerred the case**
To Rustic **Os**teopath
He listened to **Conflict** with **Rahim** & **Irfan**
They **Neither Paid Petty** cash
Nor **Could Arrange Aurum**
They were punished for **Zunzibar**
Canada & **Hague**

Lanthanides

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu

Poem for Lanthanides

Lady **Ce**sar **Pr**incess
Nee**d**s a **Pram**
and **Sm**all **Eu**ropean **G**ol**d**en **Tab**
Pram for the **Dy**na of **Ho**lland
Tab for **Er**rich **TommY** **bobby** & **Lu**ssac

Actinides

Ac	Th	Pa	U	Np	Pu	Am	Bk	Cf	Es	Fm	Md	No	Lr

Poem for Actinides

Ac ThaPa was **UN**po**Pu**lar
Among his **Country** **men**
When got the **Break** in **Cal**ifornia
He **Es**tablished name and **Fame**
His hard work and sincerity
Made him **No**ble **Laureate**

Contributed by

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Science News

Nobel Awards 2001

The respective Nobel Committees announced Nobel Prize in physics, chemistry and that for the medicine and physiology for the year 2001 in the month of October 2001.

Three US-based researchers have won the Nobel Prize in physics for creating a new state of matter — a kind of super-cold gas that could help scientists build tinier electronics, faster computers and ultra-precise clocks and measuring instruments. Eric A. Cornell, of the National Institute of Standards and Technology in Boulder, Colorado, has shared the award with Carl E. Wieman of the University of Colorado in Boulder and Wolfgang Ketterle of the Massa-chusetts Institute of Technology. Cornell and Wieman are Americans while Ketterle is a German working in the USA.

According to the citation of the Royal Swedish Academy of Sciences the Colorado researchers — using ordinary lasers disc players and a magnetic field — and Ketterle, made gases so cold that multiple atoms began to behave as one, or 'sing in unison'. The scientists call the atoms formed by them a Bose-Einstein condensate, a state of matter different from solids, liquids and gases. The Bose-Einstein condensate takes their name from the Indian physicist S.N. Bose and Albert Einstein.

Three scientists — two Americans and a Japanese — have shared the Nobel Prize in chemistry. Their work has facilitated to turn sophisticated life-saving drugs into affordable treatments for millions. William Knowles and Barry Sharpless both from America share the award with Ryoji Noyori who is from the Nagoya University, Japan. The key research carried by the Nobel award winners has been used to create numerous products, including antibiotics and anti-inflammatory and heart drugs, according to the citation issued by the Royal Swedish Academy of Sciences. The contributions made by the three scientists, working independently, have proved to be crucial in speeding up chemical reactions to provide large quantities of very pure molecules needed for the mass production of drugs, thereby making these medicines accessible to a vast market.

Cancer cell pioneers Leland Hartwell of the United States and two Britons – Tim Hunt and Paul Nurse – are the three scientists who have received Nobel Prize in chemistry for the year 2001. All three have spent years unravelling the way in which cells reproduce, with the hope of working out a way to understand and halt the uncontrolled growth, which characterizes cancer growth.

Professor Hurtwell, from the University of Washington in Seattle, USA, laid the groundwork with experiments using yeast cells starting three decades ago. He discovered a gene that plays a key role in the cell multiplication process.

The two co-recipients, Sir Paul Nurse who is the Director of the Imperial

Cancer Research Fund and Dr Tim Hunt from the charity's Cell Cycle Control Laboratory, made discoveries relating to genes and body chemicals in humans, which have a major role in the natural cycle of a cell's life and reproduction. A successful cell cycle is needed for the transfer of undamaged genetic material from one generation of cells to the next. Failure to do this could be a factoring the development of cancer cells - and the genes identified may point the way to treatments in future.

PSLV Launch Successful — Places Three Satellites in Orbit

In its sixth flight conducted on 22 October 2001 from SHAR Centre, Sriharikota, ISRO's Polar Satellite Launch Vehicle, PSLV-C3, successfully launched three satellites — Technology Experiment Satellite (TES) of ISRO, BIRD of Germany and PROBA of Belgium — into their intended orbits. This is the second time that PSLV launched three satellites simultaneously; in the previous launch in May 1999 PSLV had launched India's IRS-P4 along with German DLR and Korean KITSAT-3.

While TES and BIRD (Bispectral and Infrared Remote Detection) satellites were placed in the 568 km sun-synchronous orbit, PROBA (Project for On Board Autonomy) was placed in an elliptical orbit with a perigee (nearest to earth) of 568 km and an apogee (farthest to the earth) of 638 km. The higher orbit for PROBA was achieved by firing the reaction control thrusters of PSLV-C3 founh stage.

PSLV-C3 lifted off Sriharikota at '10.23 with the ignition of the core first stage and four strap-on motors; the remaining two strap-on motors of the first stage were ignited at 25 second after the lift-off. After going through the planned flight events including the separation of the ground-lit strap-on motors, the air lit strap-on motors and first stage separation, the ignition of the second stage, separation of the heat shield after the vehicle had cleared the dense atmosphere, third stage ignition, third stage separation, fourth stage ignition and fourth stage cut-off, the satellites were systematically injected into the orbit as per plan.

The first satellite to be ejected into the orbit was ISRO's TES at a height of 572 km after 970 seconds from lift-off. About 40 seconds later, the second satellite, BIRD, was separated from the fourth stage and equipment bay. Subsequently, the fourth stage reaction control thrusters of PSLV was fired to raise the orbit of the equipment bay along with the third satellite, PROBA, to a height of 590 km before the satellite was ejected, 1658 second from lift-off. The satellites were ejected after suitable reorientation of the equipment bay to avoid any collision between the satellites and the fourth stage-equipment bay combination. All the three satellites have been placed in their intended polar sun-synchronous orbits.

It may be noted that PSLV was developed by ISRO to place 1000 kg class Indian remote sensing satellites into Polar Sun-synchronous Orbit (SSO). Since the first successful flight conducted in October 1994, the capability of PSLV has been enhanced from 805 kg to 1200 kg into 820 km SSO. PSLV also has the capability to launch 3500 kg satellites into 400 km low earth orbit and 1000 kg satellites into Gee-Synchronous Transfer Orbit

ECIL Develops Conveyorized Parcel Viewer System

The Conveyorised Parcel Viewer System has been developed by the Electronic Corporation of India Ltd. (ECIL), a public sector undertaking of the DAE. The system developed by the ECIL is similar to in concept the x-ray baggage inspection systems installed at the airports. The new system is compact and can be moved and set up anywhere. It is ideal for inspection of concealed parcels or packages and detection of concealed weapons, firearms or other such prohibited items without opening them. It is especially useful in high risk locations such as post offices, important buildings and all other places where sealed packages are handled and have high security. The present security environment across the world very much needs equipment to help the security agencies to forewarn such kinds of threats. The machine is capable of detecting presence of powdery substances in sealed packets. If the envelopes containing powdery substances are put through this machine, the image shown by the machine reveals their presence.

(*Source:* Nuclear India)

Computing with DNA Comes a Step Closer

Scientists had built the first programmable computer made from the molecule which carries our genes has brought the vision of computing with DNA one step nearer.

Israeli researchers have developed a DNA computer so tiny that a trillion of them could sit in a drop of water and perform a billion operations per second. The idea of following Mother Nature's lead and using DNA to store and process information took off in 1994, when Leonard Adleman of the University of Southern California, USA, first used DNA in a test tube to solve a simple mathematical problem.

Since then a number of research groups around the world have been active in the field — which fuses biology and information technology — in a bid to harness the inherent ability of strands of DNA to perform trillions of calculations at the same time. That massive simultaneous problem-solving at a nanoscale is a potential way of getting round the limits of the silicon chip, which scientists believe cannot be scaled down much further.

The famous double-helix molecule found in the nucleus of all cells can hold more information in a cubic centimeter than a trillion music CDs, with data stored as a code of four chemical bases —adenine, thymine, cytosine and guanine, or A,T,C and G. These chemical 'letters' like to link up with particular other ones, which means strands with complementary letters stick together. These linkages can then be 'read' using naturally occurring enzymes, giving scientists a way of finding hidden patterns in complex data sets.

The achievement of researchers at Israel's Weizmann Institute in getting DNA to . perform calculations automatically follows a breakthrough in the year 2000 by a team at the University of Wisconsin, USA, who successfully anchored strands of DNA to a glass slide, opening the door to eventual DNA computer chips. But harnessing DNA's potential as a microprocessor remains a challenge and many scientists believe it will only ever complement rather than replace silicon-based computers.

Some of the researchers contemplate that future computers may be a hybrid machine – a hybrid between the existing processing devices coupled with the DNA as a coprocessor. According to Martyn Amos, a lecturer at the University of Liverpool, UK in future we might have hybrid machines that use a lot of traditional silicon for normal processing tasks but have DNA coprocessors to take over specific tasks for which it is best suited

While a conventional desktop PC is designed to perform one calculation very fast, DNA strands produce billions of potential answers simultaneously, which may make them suitable for solving 'fuzzy logic' problems that have many possible solutions rather than the either/or logic of binary computers.

Although DNA offers an intriguing new medium for computing, scientists have yet to crack the problem of 'scalability', or the capacity to expand to solve huge problems that existing computers now do.

Adleman's initial test-tube calculation solved the so-called 'travelling salesman problem' by working out the shortest route between seven cities linked by 14 one-way roads. All possible permutations were created in a test tube and the correct ones filtered out using bio-chemical reactions. The snag is, the bigger the problem the more DNA you need — and, with current techniques, the numbers can get out of hand. Amos has estimated that if one scales up Adleman's problem to 200 cities from seven, then the weight of DNA required to represent all the possible solutions would exceed the weight of the earth.

That is one of the reasons why is focus of future devices is still on other ideas such as carbon nanotubes and quantum computing, based on atoms rather than biological material. However, it seems most unlikely that DNA computer would be available at common places in near future, the clever molecule may yet have other applications that could bring the technology closer to the pharmaceutical industry.

Professor Ehud Shapiro of the Weizmann Institute, the Head of the Israeli research team, believes DNA nanomachines could in the future operate within human cells, monitoring potentially disease-causing changes and synthesizing drugs to fix them. According to him the living cell contains incredible molecular machines that manipulate information-encoding molecules such as DNA and RNA (its chemical cousin) in ways that are fundamentally very similar to computation. Since it is not yet known as to how to effectively modify these machines or create new ones, the trick is to find naturally existing machines that, when combined, can be steered to actually compute.

Another use could be in building diagnostic tests inside a 'smart' bacterium by re-engineering its genome to include a small logic circuit that could, far example, be activated by the presence of a certain chemical. The whole field of DNA computing remains at the very early 'proof-of-principle' stage but could start to become a reality in the next five to 10 years, Amos believes.

Tiny Computers, Genomes Top 2001 Science List

Breakthroughs in making tiny computers, progress on decoding the human genome and work on unraveling some of the Sun's mysteries topped the list of notable scientific achievements for 2001, according to the internationally known magazine *Science.*

New drugs to treat cancer, a decision that people are indeed responsible for global warming and research on 'cold' superatoms also made the annual top 10 list put out by *Science*, published by the American Association for the Advancement of Science.

But the work on the little computers, called nanocomputers, was adjudged to be outstanding by the team of selectors that included Phil Szuromi, a supervisory senior editor of the magazine. Although true computers the size of a few molecules is years from becoming reality, their potential according selectors were easy to visualize.

These tiny computers as of now can be imagined something like powering a sensor that would be inside one's body to monitor the level of a drug or to monitor the level of insulin or in the form of a little embedded pack to deliver drugs. Other mundane applications of these tiny devices might be 'smart' lights that could automatically sense and adjust the lighting level, as per the need or moods of an individual.

Yu Huang and colleagues at Harvard University in Cambridge, Massachusetts, were the first to report that they have made tiny wires, 1,000 times thinner than circuits, that can be scratched onto a silicon chip using today's technology. Jan Hendrik Schon and colleagues at Bell Laboratories created diodes and transistors on the tiny scale. Groups at the University of Delft in the Netherlands, Pennsylvania State University, IBM and elsewhere reported making the equivalents of switches, wires and transistors on a molecular level this year.

The other advances identified by the Association are:

- The publication of detailed sequences of the human genome, the collection of all the genes, in February 2001.
- The development of targeted drugs that can find and correct the defects in cells that causes cancer. One, Gleevec, is being marketed by Novartis to treat a form of leukemia.
- Work on super-cold 'superatoms'

called Bose-Einstein condensate. Eric Cornell and Carl Wieman won the 2001 Nobel Prize in Physics for their work in the field, and other teams reported on continued advances.

- The declaration by the International Panel on Climate Change that human beings are, for sure, one main cause of global warming, the deterioration of the atmosphere caused by green house gases such as carbon dioxide.
- In a related area, the discovery that the United States has a huge 'carbon sink' – a mass of territory covered with plants that soak up extra carbon dioxide from the atmosphere, perhaps mitigating the effects of climate-changing global warming.
- Work in understanding the role of RNA in the cell. RNA was once seen as the working arm of DNA, which carries the genetic code, but studies show it can 'silence' genes and even help cut them up.
- A discovery that neutrinos, virtually massless particles, convert into other forms known as muon and tau before they leave the Sun — solving a 40-year-old mystery.
- Work on new superconductors — materials that can transmit electricity with very little resistance, thus preserving the amount used.
- Advances in understanding how brain cells called neurons signal to one another.

Photo-electron Beamline Becomes Operational

A photo-electron beamline has been constructed by the Inter-University Consortium for Department of Atomic Energy (DAE) Facilities (IUC-DAEF). The photo-electron beamline is to be used with the 450 MeV electron synchrotron radiation source Indus -1 that has been in operation since 1999 at the Centre for Advanced Technology (CAT) at Indore, Madhya Pradesh. This source gives synchrotron radiation from soft x-rays, vacuum ultra-violet (VUV) rays to infrared. To use this radiation from Indus-1 for different experimental work, six beamline and experimental stations are planned to do the experiments in the soft x-ray, UVU and the visible range. The two beamlines that have become operational are a part of this programme.

(*Source:* Nuclear India)

Milk-derived Vaccine Protects against Malaria

A group of researchers claimed to have developed a malaria vaccine purified from milk produced by genetically modified mice successfully protects monkeys against the disease. The team have also modified goats to excrete the protein in their milk, raising the prospect of a cheap way to mass-produce a malaria vaccine to save millions of lives each year.

According to Anthony Stowers of the US National Institute of Allergy and Infectious Disease who directed the new research in collaboration with a biotech company a vaccine must not only be effective, it must be cheap to manufacture if it is to be used in those countries that are hardest hit by malaria. Using transgenic animals to achieve both ends is an exciting possibility. If it works, a herd of several goats could conceivably produce enough vaccine for all of Africa, according to him.

Clinical trials using the milk-derived vaccine on people could begin in 2003. However, Stowers thinks the existing vaccine will have to be modified to include more proteins to produce effective protection in the field. Regina Rabinovich, Director of the US-based Malaria Vaccine Initiative had observed that the results are 'very encouraging'. However, she warns that it is very hard to model malaria infection in animals. She asserts that how useful this is cannot be known until some formulation is tested in human trials.

Deadliest Parasite

Research team has created a strain of mice carrying a form of the gene for a surface protein from the deadliest malaria parasite, Plasmodium falciparum. The gene was designed to be switched on by cells that line the mammary glands, so the protein, called MSP1 42, would be screted into the animals' milk.

The researchers found that the mouse milk contained very high levels of MSP1 42. They got the equivalent of 900 milligrams per litre — and whereas they were contemplating vaccinating a person with about 25 micrograms. The team then studied the effectiveness of the purified vaccine on 12 Aotus nancymai monkeys — a species that is susceptible to lethal infection with the *P. falciparum* parasite. Only one of five immunized animals contracted the disease. But six out of seven unvaccinated monkeys had to be treated for virulent malaria. In terms of the protection induced in the monkey malaria models, our vaccine is one of the best, claims Stowers. He further adds that it is possible to produce relatively small amounts of the vaccine using a standard lab technique. But this is a fairly complex, expensive methodology.

Goat Vaccine

Initial tests on a modified herd of goats created by the research team shows that they also produce high levels of the protein in their milk. The team will now try the goat-milk-derived vaccine in monkeys. Several teams around the world are working on experimental malaria vaccines. Pharmaceutical giant Glaxo-Smith-Kline, using standard laboratory techniques, has developed the most clinically advanced. This vaccine recently showed promising results in a field trial in Gambia.

As the malaria kills people in predominantly the poorest parts of the world, Rabinovich observed that malaria researchers must strive to find a vaccine that not only works, but also is cheap. The production of the protein in goats' milk is potentially a very efficient, scalable and cost-effective production system.

Stem-cell Cloning Holds Promise in Cancer Research

In the near future a team of scientists in the United Kingdom will make the first application for a government licence to carry out the cloning of human embryos.

Literally opening a Pandora's box of medical wonders, although not without important ethical implications, their objective will be to initially use spare IVF (in-vitro fertilization) embryos and later clone early human ones as the main component of research on embryonic stem (ES) cells, the parents of all cell types.

This research will offer the means to repair damage caused by Alzheimer's and Parkinson's desease, stroke, spinal cord injuries, heart ailments and diabetes.

The Bio-industry Association of UK has said that human trials of ES treatment could start within three years. But the team at Sheffield University, Northern England, emphasized that they were not providing anything in the nature of a 'quick fix'.

Professor Peter Andrews of Sheffield University says that he finds it difficult to envisage routine use of the technology on other than selected volunteers in the next 10 years. He is the first UK scientist to work on human ES cell lines in culture. His work follows extensive research of a peculiar type of tumour called a teratoma. These contain a haphazard mixture of tissues, such as bone, nerve and muscle, as if from an embryo whose development became catastrophically scrambled.

Less-dramatic but highly malignant forms occur more commonly as testicular cancers in young men. Study of these cancers has led to the ability to grow ES cells as well as the prospect of their use as remarkable sources of tissue for transplanation therapy. The malignancy of testicular teratomas is mainly caused by a stem cell known as an embryonal carcinoma (EC) cell. During the 1970s, lines of EC cells from mouse teratomas were established in culture. It was soon shown that EC cells closely resemble ES cells, the forebears of all the different cell types that make up the developing embryo.

The way that both have the potential to turn into more specialized cell types – a process known as differentiation – was of particular interest to scientists interested in understanding how embryos develop. Indeed, it was through paralel studies of teratomas and embryos that scientists were eventually able to isolate ES cell lines directly from early mouse embryos.

Professor Andrews cautions that while many of the processes that control embryonic development are shared by mice and men, despite millions of years of separate evolution, some must be unique to humans. Therefore to understand better how human embryos develop and how the process can sometimes go awry, we must study human embryonic cell differentiation directly.

It was with this in mind that some 20 years ago, Professor Andrews and colleagues began to work with EC cells from human testicular teratomas, first at the Wistar Institute in Philadelphia, United States, and then at Sheffield University. One line that they studied, called NTera2, is particularly prone to differentiate into nerve cells, making it a useful tool for studying neurogenesis.

Scientists at the University of Pittsburgh are investigating whether or not transplanting neurons derived from EC cells into the brain can help alleviate the suffering of stroke patients. EC cells are cancer cells and there are concerns about whether their derivatives are truly 'normal'. This provided the basis of the recent excitement surrounding the successful derivation of human ES cell lines flom 'excess' embryos that would be destroyed following IVF treatment for infertile couples.

These are clearly different from mouse ES cells, underlining the importance of being able to use human ES cells to investigate human development. Such embryos have been used for the past decade for strictly defined studies on infertility, congenital disease or miscarriages, contraception and screening embryos for genetic defects.

The Sheffield team is to apply to extend its studies. Early embryos, consisting of 100 or so cells, would be dismantled to obtain their stem cells to see how they could be used to create heart muscles, blood cells and nerve cells.

ES cells may also provide a variety of tissues for the transplant surgeon. Much has recently been heard about 'adult' stem cells and what they might achieve, implying that use of ES cells could be avoided. But we still have very little understanding of these and it is far from clear whether or not they will be as useful as some recent reports have suggested.

Professor Andrews asserts that it is likely that ES cells and adult stem cells will provide complementary tools; it is far too early to decide upon their respective benefits. In his opinion cloning technology adds very little at this stage. Ultimately, researchers may indeed find this approach useful to match ES cells to their potential donor. However, there is still much to be done to assess just what ES cells can do, first.

(Courtsey: Spectrum Online)

(Compiled and Edited by R. Joshi)

Book Review

The Fascinating World of Physics

***The World of Physics*, Vols. I, II & III by Jefferson Hane Weaver. Publisher: Simon and Schuster, New York, $29.95 each.**

Physics, literally, was born in the ancient Greece. Although the Greek philosophers were seized of the structures all-around them they did not understand that no structure could exist without forces. So, they had no idea of the nature of forces at all. The study of motion, in Greek science, was essentially a study of kinematics and not dynamics. The best example in point is Greek astronomy which dealt only with the motion of celestial bodies without reference to the cause of these motions. Although Greeks studied various physical phenomena they never sought general principles and laws that could explain many different phenomena. This was an inherent limitation in the Greek science because the Greeks did not attempt to unify, as each phenomena was treated independently. Even Aristotelian physics treated motion in terms of a 'contact-action' principle. This was based on the concept of 'unmoved first mover'. According to Aristotle, a body moved due to its remaining in continous contact with another body which provided the driving force.

Historically, it was the work of Galileo and Newton that laid the foundation of physics. Their work for the first time revealed the relationship between the motion of a body and the forces acting on it. Indeed, force is a physical entity that must be incorporated in the description of motion. It is the essence of Galileo's principle of inertia and of Newton's three laws of motion.

However, Newton's discovery of the force of gravity (and the inverse square law governing this force) was his greatest achievement. Using his law of gravity and his second law of motion, Newton was able to deduce Kepler's three laws of planetary motion. This changed the methodology of scientific research for ever, for it showed that a correct physical law combined with logic (mathematics) can reveal new truths. This brought mathematics directly into physics as a very powerful analytical tool.

The Newtonian methodology of combining mathematics with physics, leading to specific deductions, shows the universality of physical laws and reveals new universal laws.

The Newtonian physics reigned supreme until the end of the nineteenth century when it was overtaken by two revolutions, the first sparked off by the Einstein's theory of relativity and the second by the quantum theory.

The quantum theory and the special theory of relativity stimulated an incredibly rapid development of both experimental and theoretical physics in the first two decades of the twentieth century with the experiments outstripping the theories. The most remarkable results were the discovery of the electron and the proton by J.J. Thomson, of x-rays by Rontgen, of radioactivity by Bacquerel, the Curies and Rutherford, of the nuclear atom by Rutherford and the vast proliferation of atomic spectroscopy.

The theoretical discoveries that stemmed almost entirely from the quantum theory and the theory of relativity, were spectacular in their impact on both science and philosophy. Einstein extended the quantum ideas first introduced by Max Planck in 1900 that the energy of matter is discrete or quantized, to explain the photoelectric effect. By applying the quantum theory to solids he was able to demonstrate how correct values for their specific heats could be obtained.

The jewel in quantum theory's crown was, however, Bohr's planetary model of the atom with its discrete orbits for the electron circling the nucleus. This was a direct application of the quantum ideas of Planck and Einstein to atomic dynamics. Without Planck's constant, Bohr pointed out, atoms could not exist not could they emit the discrete special lines. The Planck's constant, therefore, became a benchmark of the quantum physics.

The relativity theory was born in 1905 when Einstein tried to explain the null result of the famous Melcson-Moley experiment on the speed of light. Through his special theory of relativity Einstein combined space and time into a single concept known as the space-time continuum. From his special theory, he produced his great creation, the general theory of relativity.

The general relativity theory of Einstein views the space-time manifold as curved and so it is governed by non-Euclidean geometry. Gravity, in Einstein's scheme of things, is therefore not a force but the curvature of space-time.

The general theory of relativity initiated a new and powerful attack on the cosmological problem which Newtonian theory could not even begin to solve. One of the most remarkable predictions of the general theory was the expansion of the Universe which is best described in Hubble's famous law. The full impact of the Einstein's general theory on physics was not felt, however, until the recent era when black hole physics was studied intensively by such stalwarts of physics as Wheeler, Chandrasekhar, Hawking and Penrose.

During the period of rapid growth of relativistic physics, quantum physics was also being expanded in its applications to atomic dynamics and structure. The primitive Bohr model of the atom gave way to a more complex model, called the vector model of the atom. Although this model explained many of the observed features of the spectral lines of the atom, it had some serious deficiencies. Also, the model was found unsatisfactory from a general theoretical point of view, for it was an ad hoc mixture of Newtonian mechanics and quantum physics. A whole new theory was developed in the 1920's starting with de Broglie's theory of particle waves, which completed the remarkable saga began by Planck and Einstein. Just as they had discovered the particle character of waves, i.e. of energy, de Broglie discovered the wave character of particles, i.e. of matter.

Thus, the circle was completed and the wave-particle duality became part of physics.

With de Broglie's discovery of particle waves, whose wavelengths are given by Planck's constant divided by the particles' momenta, the new quantum mechanics was developed quite rapidly in two different forms, viz. the matrix mechanics of Hiesenberg, Born and Jordan; and Schrodinger's wave mechanics. It was later shown by Schrodinger and Dirac independently that matrix mechanics and wave mechanics are completely equivalent. The name quantum mechanics was then coined to cover both the matrix and wave mechanics.

While the quantum theory was reaching its maturity, nuclear process was being born. That the principles of quantum theory apply to particles in a nucleus was for the first time demonstrated by George Gamow in 1928 by applying the Scrodinger wave equation to the α-particles (helium nuclei) in the uranium nucleus. During this period Rutherford's experimental research involving the bombardment of nuclei with protons and α-particles demonstrated conclusively that nuclear transformations can be produced in the laboratory. The question as to the constitution and structure of the nucleus, however, still remained and Rutherford was first to suggest that the nucleus consists of massive neutral particles in addition to protons.

The big breakthrough in nuclear physics, however, came with the Chadwick's discovery of the neutron, the neutral counterpart of the portion, and the floodgates of experimental and theoretical nuclear research were thrown open.

The discovery of the nucleus and the subatomic particles — electron, proton and neutron — was followed by the discovery of a spate of elementary particles. Using high-energy accelerators, the particle physicists have now been able to probe deep into the proton and the neutron to reveal their quark structure. Quarks of six different types have now been discovered.

The various particles, the fundamental constituents of matter are, however, not all different in their interactions with one another. In fact, there seems to be just four kinds of interaction between particles: strong, electromagnetic, weak and gravitational. Today, in the far frontiers of physics, many researchers are concentrating their efforts on the formulation of a Grand Unified Theory (GUT) that would theoretically identify all matter and energy in a single set of equations. This exercise of unification was started by Einstein who tried, though without success, to unify gravity with the electromagnetic field. Electromagnetic and weak interactions, however, have been unified leading to a single electro-weak force interaction. If some day the unification of the four basic interactions is achieved by the physicists we will be able to explain not only the structure of proton, neutron and electron but also the big-bang, the cosmic background radiation and the expansion of the Universe.

The great achievements in physics as summarized above have been covered in the three volumes of *The World of Physics*. Physics from antiquity to the end of the nineteenth century has been covered in Volume I while the development of the theory of relativity and quantum theory, which spanned the first half of the twentieth century, has been dealt with in Volume II. The applications of these theories to a variety of phenomena such as black holes and the evolution of the Universe have been discussed in Volume III.

The entire three-volume work is divided into 26 parts arranged chronologically and topically. Each of these parts begins with a brief general introduction to the subject matter of that particular part. Each of the essays within each part is preceded by a short commentary or a head note that provides biographical information about the author and explains some of the concepts in the essay itself.

Volume I, the Aristotelian concepts and the Newtonian system, starts with some fundamental ideas about physics. The three essays, viz. 'Basic Physics' by Richard P. Feynman, 'On the Meaning of Physical Theories' by Max Born and 'The Fundamentals of Theoretical Physics' by Albert Einstein indeed are brilliant not only in their exposition but also due to the excellent thoughts and ideas conveyed through them. Other essays worth reading in the collection comprising Volume I are included under the titles 'The Copernicus Revolution', 'Newton's World', 'Energy', 'Entropy' and 'the Electromagnetic Field'.

Volume II, the Einstein universe and the Bohr atom, serves indeed as a treasuretrove, for the various essays beautifully deal with the two revolutions that gave birth to the modern physics — the relativity theory and quantum mechanics.

Volume III, the Evolutionary cosmos and the limits of science, concentrates on the developments of the twentieth century and the applications of the principles of relativity and quantum theory to such phenomena as stars, black holes and the evolution of the Universe.

Opening with essays written by Philip Jourdian, Normal Campbell, Eugene Wigner and Pierre Duhem, that examine the relationship of mathematics to physics, Volume III then moves on to essays by Carl Friedrich von Weizsacker, Albert Einstein and Steven Weinberg about the concept of unity in physics. In particular, essays by Abdus Salam titled *Gauge Unification of Fundamental Forces* and Sheldon Glashow titled *Towards a Unified Teory: Threads in a Tapestry* make a very interesting reading indeed. Then, there are illuminating essays on stars, black holes and the evolution of the Universe. Some of the notable figures who have written these essays are Albert Einstein, Edwin Hubble, George Gamow, Steven Weinberg, Hermann Bondi, Hans Bethe Lloyd Motz, John Wheeler, Roger Penrose and Stephen Hawking. Other essays range from cosmic numbers to interdisciplinary works exploring physics and philosophy by thinkers as versatile and diverse as Max Planck, Neils Bohr, Werner Heisenberg, Betrand

Russel, James Jeans and many other eminent figures.

The essays that find inclusion in the three-tier work under review are non-mathematical so that they are easily comprehensible to the general, lay reader. It intends to strike a pleasing balance between an encyclopaedia, a source book, a textbook and a history. All the three volumes of the work will prove useful not only to the working and teaching physicists who want to understand the roots of their sciences but also non-physicists who seek an understanding of the universe. The work will be a valuable addition to personal libraries of scientists and laymen alike.

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